Review
UDC 331.215.56

The tournament model: an empirical investigation of the ATP Tour*

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Abstract

In the competitive labor markets, labor is hired and paid based on their value of marginal product. However, when we observe and compare wages between top level managers, difference in those wages are very large. High wage differentials are needed to induce the incentive to provide substantial effort from the start of their careers. Structure of the marginal payoffs in professional tennis tournaments does not correspond to tournament theory. Marginal payoffs increase, but at the decreasing rate, and in the final round, final marginal payoff drops. Percentage change in marginal payoff is larger in the semi-finals than in the finals. Along the same lines, top four finishers receive less than 50% of the total purse, around 40%. Finally, output from regressions on total purse and marginal payoff (spread) show mixed results. In some instances players' effort is related to the purse instead of marginal payoff, which contradicts the theory. In other cases, players' effort is dependent on both variables, purse and marginal payoff. Thus, results are rather inconclusive.

Key words: *tournament model, marginal payoff, effort level, tennis tournaments*

JEL classification: *J01*

1. Introduction

Literature on tournament models is rather small, but growing. More recent publications are mostly oriented toward empirical analysis, testing the models developed by Lazear and Rosen (1981), Nalebuff and Stiglitz (1983), O'Keeffe, Viscusi and

* Received: 12-11-2006; accepted: 23-04-2007

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2 Author is greatly indebted to Dr. Mike Maloney for his comments and guidance, as well as participants of workshops at Macon State University, GA and at Southern Economic Association meeting, Charleston, SC.

Zeckhauser (1984), and Rosen (1986). Tournament theory was developed on the simple observation that workers in a firm, in some instances, are not paid on the basis of value of the marginal product, but some lower amount at the early stages of their careers, and then, higher amount at the later stages of their career. Basically, using sport's environment as an example, individuals enter as minor league contestants, and the best contestants are promoted into major league. Once in the major league, their pay is again based on the performance relative to other individuals, rather than solely on the output. For instance, the difference between chief executive salary and the salary of a vice president is extensive. More explicitly, the difference in the pay of chief executives and their immediate subordinates seems to be greater than the difference in their abilities or outputs (Dye, 1984). This is suggesting that chief executives are the winners of a contest and therefore they receive first prize, while their subordinates are in a sense losers, and receive loser's share. It is important to realize that the difference between the first prize and the second prize, or the spread, will determine how much effort individual is willing to supply, given his talent and the ability. Contestants who succeed in attaining high ranks in elimination career ladders rest on their laurels in attempting to climb higher, unless top-ranking prizes are given a disproportionate weight in the purse (Rosen, 1986).

This paper is analyzing the tournament model in another sporting event, men's professional tennis. Professional tennis tournaments perhaps fit the concept of a tournament model better than any other sport since they are based on a concept of single elimination, winners move forward with a chance to obtain a higher reward, while losers receive their loser's share of total purse. Spread between prizes exists and it should be structured in a way to motivate players' performance and the total quality of play. On one hand, players try to maximize their utility subject to some effort level constraint. As they increase the effort level, costs associated with it will increase as well. By equating the marginal cost of additional effort supply to the marginal benefit, which is a higher prize that they can obtain, they would maximize the utility. On the other hand, tournament owner, or the organizer will behave just like a firm. For simplicity, let's assume a competitive environment. Tennis players are the inputs for the production process, a match. Players' inputs are their forehands, serves, drop-shots and so on. Owner's goal is to maximize his profits subject to a purse constraint. Purse will determine who enters the tournament which is actually very important for his revenue stream, since public, TV contracts, and sponsors decide to contribute before the event starts, once they know, or once they can forecast who will play, not during the tournament. In some smaller tournaments that might not be the case. Thus, owner of the resources will try to maximize his profits by manipulating total purse. Question than arises from this analysis; why should the owner of the tournament be concerned about the spread and, indirectly, the effort level of the players since major percent of his total revenue comes in before the tournament starts? Sponsors invest before the tournament starts and the fees depend on the tournament's exposure to the audience, public in general purchases tickets before the event starts in general to hedge against sold-out problem and ability to see their favorite players, and finally, television managers do not pay to the owners based on the viewership after the tournament, but before the tournament. In a sense, it is a risky investment by the television, sponsors, and public as well. Tournaments do price discriminate when selling tickets to the public. Usually, ticket prizes increase as the time of the day increases or as the rounds left to be played in a tournament decrease. Reason for this is that higher ranked players are scheduled to play later in a day, and it is assumed that later rounds will present better matches where seeds are suppose to play against each other. With all this in mind, tournament owners should worry about setting the correct spread, which will in turn cause players to fully invest their resources and provide quality play, for the following reason. Owners of the tournament will try to maximize their profits by estimating their revenue over a long period of time, not just one tournament. In a Fischerian sense, long-run profits will be as important as the short-run profits. Thus, owners will try to build a solid reputation by providing consistently good service and entertainment. The process is similar to the process when firm is developing a brand name. Efficiently developed spread will perhaps make players supply optimal amount of effort, which will produce high quality and entertaining duels. Happy fans and high ratings will definitely secure good contracts for next year's event.

2. Empirical tests of tournaments

Empirical analysis of tournament models is rather small. The most obvious reason for this fact is that it is difficult to apply tournament theory model in the firm's environment and produce some meaningful results, since it is difficult to measure worker's effort level in firm's setting. Small number of papers rather examined the compensation of corporate executives for evidence of rewards based upon own firm performance relative to that of other firms in the same industry (Jensen and Murphy, 1990; Gibbons and Murphy, 1990; Antle and Smith, 1986). Even though, these papers confirm that relative performance matters, which is an important feature of tournaments, their work did not actually test the theory of tournament model. Main, O'Reilly, and Wade (1993), pioneered with their work in testing tournament model in actual, firm, setting. Also, sport arenas do provide us with numerous examples of tournament setting, in which effort by players could easily be measured, since it is based on some rank, place, lowest time, or highest score.

Main et al. (1993) provided a study that reports the results of an empirical investigation of executive compensation. Their results are consistent with the operation of tournaments, or the concept of ever larger rewards to motivate those at the highest organizational levels. They found that for the years 1980-84, CEOs' (chief executive officers) earned the level of pay (base plus bonus) that was some 141% greater than that enjoyed by their immediate subordinates. They also found that the ratio of pay between levels seems to increase markedly as one moves up the corporate hierarchy.

Study done by Knober and Thurman (1994) comes very close to the actual, firm setting since they use data from production of broiler chickens. They found, that growers respond to different payment structures with different levels of effort. Thus evidence shows that incremental rewards, not absolute levels, determine effort. In other words, changes in the level of prizes that leave prize differentials unchanged will not affect performance. Secondly, Knober and Thurman found that in mixed tournaments, more able players will choose less risky strategies than less able players. Last empirical result suggests that tournament organizers will attempt to handicap players of unequal ability or homogenize tournaments to avoid the disincentive effects of mixed tournaments.

Further support of the tournament model is found in the empirical investigation of professional golf tournaments played in the United States and in Europe (Ehrenberg and Bognanno, 1990a, 1990b). Both papers test the same hypothesis using different data from PGA Tour. Here the structure of the tournament, the outcome of player's actions, and features of the environment such as weather and course rating could be observed. Major hypothesis of both papers is based on the Lazear and Rosen (1981) and Rosen (1986) theoretical work regarding prize structure. Test results are the following: more difficult courses, either higher par or longer yardage, are associated with high scores; the better the player, which is measured either by his scoring average on all rounds played during the Tour year, or by average number of strokes per round worse (+) or better (-) than par for all rounds during the Tour year (both variables measure player's ability), the lower the player's score will be.

Moving from golf competition to car racing competition, an interesting study on tournaments model was conducted by Becker and Huselid (1992). Auto racing, in this case they used the data from NASCAR and IMSA races, is characterized by across-tournament variation in both the size and distribution of the prizes. The results show that increasing the absolute prize differential going to the top finishers increased driver performance. Results show that drivers did take more risks as the spread increased, but only when the payoffs were very high.

Finally, we move from car racing to foot races, which was a study on tournament model done by Maloney and McCormick (1994). Foot races are more individually oriented than car races, thus less organization is required. Empirical results are the following; the longer the race, the slower the time per mile. When the average distance between top finishers is large, times for all finishers, even first place, are slower. In other words, overall times are slower when the finish of the race is not close. Also, the less concentrated the payout of the purse, the slower is the field. That is, when a few runners receive the bulk of the money, the finish times are faster. It is worth mentioning the fact that above study used an open, not a close event for analysis. When prizes increase, authors found that in an open event like a foot race, individuals already in the race will run faster, but also higher prizes will attract a faster field. LBO's and corporate takeovers cause firm's managers to behave like they are competing in the open tournament where the threat of turnover is always present. It is not certain that participants of the closed working environment will respond in the same manner, as participants of the open working environment, to the wage changes.

3. Data source and variables

The empirical analysis of this paper was performed analyzing the data set provided by the ATP organization, with main offices in Ponte Vedra Beach, Florida. This site has been the home for ATP since their inauguration in 1990. All the available data is stored on the IBM's AS/400 model 45. Data available through the system is on current rankings and the prize money, ranking history by player, head-to-head competition, tournament history/winners, singles activity by player (wins/losses), doubles activity by player (wins/losses), and win/loss standings in ranking order. Most of this data is collected at the site, either by the chair umpire or the ATP analyst. Besides providing statistics from the ATP tournaments, ATP also provides match and players statistics from the Davis Cup matches and Grand Slam Tournaments.

All the data was supplied by the Association of Tennis Professionals (ATP), with headquarters in Ponte Vedra Beach, Florida. Data consists of 169 professional tennis tournaments played on the ATP Tour during 1992 and 1993 seasons. In terms of tournament structure and marginal payoffs, nothing has changed since. Tournaments differ in their size regarding a draw sheet or the number of players participating. There are four different draw sizes, 32 draw, 48 draw, 64 draw, and 128 draw, which is a typical draw size for the four Grand Slam tournaments. However, the above draw sizes include the rounds in tournaments where players do not have to face an opponent in the first round. They have, so called, bye. For instance, Lipton Tournament in Key Biscayne, Florida, has a draw of 128, but only 96 players do play, which means that 32 players, seeds, have byes in the first round. These players do collect a check for advancing into second round without playing. In a sense, they receive a bonus for showing up at the tournament. Since they do not play, they do not supply any effort level to move into second round. This would cause a measurement error, and it is necessary to adjust draws for this problem. Thus, there are 121 32-draws, 14 48-draws, 1 53-draw, 20 56-draws, 3 64-draws, 2 96 draws and 8 128-draws. Multiplying the number of draws with the draw size and adding them all together, I have 7,125 observations. The data set is divided in two subsets. First one is Tourneys Data Set, and this set consists of all the relevant information regarding a match play. Second subset is called Prizes Data Set, and it contains tournament information. Variables located in Tourneys Data Set are the following: date, round(there is a maximum of seven rounds), ownrank-current player's ranking, name 1- player's name, win/lose-W for a player if he wins and L in the case he loses, opprank-opponent's current ranking, oname 2-opponent's name, time-duration of the match, def-retirements or defaults or no-show, SS1-1st set score, SS1O-1st set score for the opponent, or the number of games won, SS2, SS2O, SS3, SS30, SS4, SS40, SS5, SS5O-same as SS1 and SS1O, just different sets. In most cases matches are played two out of three sets or best of three, and sometimes, three out of five sets, or best of five. Variable FORMAT takes on value 1 if the match is played as best of three, and 0 if the match is played as best of five. TB1-tiebreak result in the first set, TB1O-first set tiebreak result for the opponent, TB2, TB2O, TB3, TB3O, TB4, TB4O, TB5, TB5O-same as TB1 and TB1O, just in different sets. ACES1 - total number of aces in a match. Aces are serves that returnee can not touch, DFS1-total number of double faults per match, or server missing both serves, BKPTS-number of break points faced (played), or server is one point away from losing his serve, BREAKS-break points converted, or server loses his serve. In professional tennis matches, speed of the ball generated by a serve is usually in excess of 100 mph. With some degree of accuracy, having a serve is an advantage, similar to having white figures in chess matches. BKPTS could be used as a measure of effort level. If both players fight hard we should expect to see the points in every game to be very condensed. Optimal reflection of a close match would be information on total number of deuce points per game. Since this statistic was not available, number of break points accomplished by both players is a good substitute. BKPTS is derived in a way so it measures the output of both players, not only one player. Thus, I took the minimum number of break points in the match, or in other words, it is a paired number of break points in a match. Thus, in the matches where only one player dominates, he has break points and eventually breaks, those break points are not included in the sample used in regressions, and only break points that match with opponent's break points are used. It is possible that in the close matches, loser has more break points than the winner, however less actual breaks. Number of break points accomplished by the losing player should cause the match to be closer. Play1-1st service points played including service aces, or the total number of points played after making first serve, Play1W-1st serve points won, Play1O-1st serves played by the opponent, Play1OW-1st serves played and won by the opponent, Play2-second serves played including service aces, Play2W-second serves won, Play2O-2nd serve played by the opponent, Play2OW-second serve won by the opponent, Play-total of service games played, PlayO-total of return games played.

Second data subset, Prizes Data Set consists of: date, tourney-tournament name, class-either an ATP event, Davis Cup, or Grand Slam tournament, purse-total tournament prize in US dollars, surface-either clay, hard, grass, or indoor carpet, location, points 1-8 for each round and for winner. Maximum is eight in the case of a Grand Slam tournament. Prize 1-8 is a dollar amount given to players for each round plus to a winner. Maximum number of recipients is 8 in Grand Slam tournaments. Variables CLAY, GRASS, HARD, and CARPET represented by the variable SURFACE are possible types of surface on which ATP Tour tournaments are played. These are dummy variables that take on values 0 and/or 1, and HARD is the base surface variable. RANKWGHT is a variable that measures the quality of the field, or the ability of the players in the draw. It is simply a sum of players' ranks, or Σ_I (ownrank$_i$ + opprank$_i$) where i=1,..., 128 for a Grand Slam tournament. Ownrank and opprank stand for own ranking and opponents ranking. RANKDIFF is the absolute value of difference in ranking between two players. It is measured as |ownrank-opprank|, and it measures player's ability with respect to his opponent ability. SPREAD is a variable that reflects the difference between two prizes. PTSPRD stands for the points spread, and is found in a similar fashion as SPREAD. Variable UPSET is a dummy variable that takes the value of zero if ownrank>opprank and opponent loses, and it takes the value of 1 if ownrank<opprank and opponent still loses the match. DRAW stands for the size of the tournament in the terms of the number of players participating. For instance, if DRAW = 128, there are 128 players participating in a tournament. Variable similar to DRAW was created, FIELD, to take into consideration byes. For instance, we could have a 64 draw but only 53 or 56 players in it. Thus mean value for FIELD should be less than the mean value for DRAW. Variable SPREAD needs more explaining than originally provided. SPREAD was derived according to Rosen's derivation (1986). According to Rosen, value of maintaining eligibility at any stage, spread, is the sure prize the player has guaranteed by surviving that long, plus the discounted sum of successive interrank rewards that might be achieved in the future matches. In other words, the incentives are determined by the discounted sum of interrank spreads. Thus, we can write, SPREAD = (EXPECTED PRICE DUE TO ADVANCEMENT - NEXT ROUND LOSER'S PAY). SPREAD variable will differ according to the size of the draw. Another important component of SPREAD variable is the probability assigned to the advancement to the next round. By looking at the draw sheet, player can tell only with certainty who will be his opponent in the first round. He can only predict who can be his next opponents in the up-coming rounds. There are instances where players do not know their opponent even in the first round. This will be the case when player waits for the opponent who comes from the qualifying tournament. When the draw is made, usually a week before the tournament, he does not know his opponent, only the day before the start of the tournament the draw is fully formed. There are, also, cases when a player has a bye, does not face an opponent in the first round, so in the second round he knows that his opponent will be the winner of the first round match. Another problem with constructing a SPREAD variable is the question of ex-ante or ex-post observation. If we look at the draw after the tournament is completed, ex-post, all the matches are completed and I know with certainty who played who, and what was the outcome. Thus, ex-post, probabilities that player faces certain opponents are known. On the other hand, tournaments are played ex-ante. Players will decide to enter the draw depending on the purse level. Once they decide to enter, the level of their effort will depend on the immediate spread, and the expected payoff of additional advancement. But, ex-ante, they will not know their opponents, and thus, they will not have perfect information in forming some probability levels. For example, player A's draw might show a likely match against a first seed in the second round and he accord-

ingly sets his effort level, assuming high marginal cost, at least in the second round. But if first seed lost before A player played his first round match, his effort level will change since his payoff changes. Marginal benefit of additional investment beyond round 1 suddenly becomes greater than the marginal cost of the investment. Thus, players will assign very little importance, or weight, to the later stages of the draw, and more importance, weight, to the early stages of the draw. As they, players, move forward through the draw, they will be updating their forecast of future opponents and assigning new probabilities to winning. Since data does not provide scheduling time of matches, in the perfect setting best players would take the court last, but due to contractual obligations towards ticket holders and most of all, TV, we know that this is not the case, I am limited to observe the draws from completed tournaments. The most approachable way to form variable SPREAD according to Rosen's theoretical work would be to assign a probability of 1/2 to each additional round. This is an accurate estimate even if we deal with heterogeneous players, since probabilities might differ between matches, but across the tournament they will average out, and we should observe closer matches as we move toward final round. Thus, variable SPREAD for the first round in a 32 draw tournament is derived as $(P_5\text{-}P_6) + 0.5(P_4\text{-}P_5) + 0.5^2(P_3\text{-}P_4) + 0.5^3(P_2\text{-}P_3) + 0.5^4(P_1\text{-}P_2)$. Variable SPREAD3 represents, let say in a 32 draw setting, the marginal expected prize for winning 1st round. SPREAD4 stands for the second round spread and expected future earnings from the rest of the available rounds. SPREAD4 is thus equal to $(P_4\text{-}P_5) + 0.5(P_3\text{-}P_4) + 0.5^2(P_2\text{-}P_3) + 0.5^3(P_1\text{-}P_2)$, and so on to SPREAD7, which would be the final match, where spread is equal to $(P_1\text{-}P_2)$. In a 64 draw tournament, SPREAD2 will reflect the first round spread, and in a 128 draw tournament, SPREAD1 corresponds to the first round match. Two important questions arise from variable SPREAD. One is, do players really look at the expected prize from winning the whole tournament, or are they concerned only with the first, perhaps, second match that they will be playing. The other one is, how accurate is to set probabilities of wining every round to be equal to 1/2. We know that 200th player in the World has less than 1/2 probability of beating 1st player in the World, and if that is the case, what would be the right way to forecast correct probability. Probability of winning will not only depend on the ability level, but also on the type of surface, two players past match record, latest results by each player, and many other exogenous factors that can not be measured. These are the problems that this paper addresses, but further research is needed for an analytical explanation. PRZDIF stands for prize difference, and it is created to see if players do perhaps care only about immediate reward. PRZDIF is created in the same way as the variable SPREAD, excluding probabilities necessary for advancement in the next round. PRZDIF1 is the prize difference between loser's prize in the first round and loser's prize in the second round. In a 32 draw setting, PRZDIF3 = $P_5\text{-}P_6$, and so on. In a 32 draw tourney, PRZDIF7 would equal the spread $P_1\text{-}P_2$. Tennis players' investment level depends on the number of points they can obtain by winning additional round, as well (see section on ATP Tour). Points are relevant variable in players' formation of effort because points are correlated with ranking, and higher ranking represents easier entry into bigger, richer, tournaments and better endorsement deals. Thus, point-spread (PTSPRD) will also influence the level of investment. Effort level will be represented by several variables. TIME is a variable that represents the actual time of a match in the tournament. Data set provided for me by the ATP Tour information center contained several errors related to the time of a match. I had to make a personal judgment when to drop the matches with too short time of a match or too long time of a match with respect to number of games played. Thus, the number of observations decreased from 6714 to 5195. The argument for TIME variable is that longer matches are associated with higher effort level. Problem with this measurement is the fact that matches are played on different surfaces, which will affect the time of the match. Thus, it is important to adjust for the surface characteristic, or results may favor clay court matches regarding effort level, but disfavor grass court matches. To solve for the problem I created a variable GAMES and POINTS. GAMES stands for the total number of games played in the match divided by the number of maximum possible sets. For instance, in the best-of-five match, total number of games is divided by five. POINTS stands for the total number of points played divided by the maximum number of possible sets played. POINTS come closest to the measurement of effort, since total number of games could produce misleading results. For instance, 6/2, 6/1 match produces low number of games, but both players could have had supplied a great deal of effort. However, only one of them got all the breaks. TIME, as well as BKPTS variables would take this problem into consideration. Variable GAMES was created by simply observing the final result and summing up all the games in the match and divided by the maximum number of sets that could have been played (FORMAT). Variables Play and Play0 provide also information on total number of service games and total number of returning games. POINTS are a sum of variables Play1, Play1O, Play2, and Play2O divided by the maximum number of sets or a FORMAT. Finally, variable PPG, which stands for points per game was created to measure some level of effort, as well. PPG is derived by dividing POINTS by the GAMES for each match. By holding the number of games constant, it would be interesting to see how level of effort changes as the number of points change.

4. Empirical analysis and results

Theoretical work laid out by Lazear and Rosen (1981), Rosen (1986), and other authors provides us with several hypotheses that could be empirically tested.

From the above paragraph several hypotheses could develop. First, as the spread level increases, effort level should increase. Coefficient should be positive. Second, as the purse level increases, number of high-ability players that enter a tournament increases. Thus, the probability to enter will be affected by the purse, since purse affects cost-benefit analysis of each player. Coefficient should be positive. Along the same lines, we can test the relationship between income effect and the entry decision. Players with large prize earnings, due to income effect, will enter lower number of tournaments than players with low prize earnings. Coefficient should be negative. Third, theory suggests that spread level should be increasing at the increasing rate. Spread between winner's prize and finalist's prize should be the greatest, and it should be narrowing down towards first round. As the number of rounds left to be played decreases, spread level should be increasing. Coefficient should be negative.

This paper addresses tournament model by observing data collected from the professional tennis tournaments. Players participating on the ATP Tour differ in their abilities. That is reflected by the rankings. It is a very rare instance among top 200 players that two of them share a common position. It is much more common to see players having the same number of points in the very low ranking places. ATP ranks about 1,000 players. Thus, we can conclude that as we move towards the top on the ranking list, ability becomes greater but at the same time more scarce. ATP Tour players, therefore, make a heterogeneous sample with abilities that are relatively known among players and tournament organizers. It does happen every year that some player has much greater ability than his ranking reflects, and as an "outsider" he does well, perhaps due to his unique style, or a fast serve. But this asymmetry will persist only in the short-run. His ranking will immediately reflect his performance and new information about him will become available. Thus, in the long-run, players and organizers know each others abilities with a great deal of certainty. Moving up or down in the rankings is rather slow, gradual process. Almost no one starts without any ranking and reaches top hundred in a year or two. Jumping from below 200th ranking into top 100 in a year is considered a tremendous task. We can conclude with certainty that sample of players in this data set is heterogeneous with known abilities. Since abilities are rather known to organizers they will not face the problem of mixed tournament, or problem of "climbing," while they are preparing a draw. Players are selected into a draw based on their ranking. If there is a 32-draw, which accepts 24 players directly and 8 qualifiers, top 24 players from the ATP Tour rank-list, which is updated weekly, will have a priority, and other players will have to qualify through a qualifying tournament, which might also have 32-draw.

This paper's objective is to test the following hypothesis:

1) Spread is increasing at the linear or increasing rate as the number of rounds left to be played decreases, but in the final round, spread should have a distinct jump

2) Top 4 ranks (2 semi-finalists, finalist, and the winner) should receive at least 50% of the total purse available in a tournament

3) As the spread level changes (increases), effort level will change (increase)

5. Results

Let us first turn our attention to the descriptive statistics. Table 1 provides us with the match statistics on first moments, standard deviations, minimum, and maximum values of the variables used in the regressions. Thus, information is based on 6,715 dual matches.

Table 1: Means, standard deviations, minimum, and maximum for regression coefficients

Variable	Mean	Standard Deviation	Minimum	Maximum
Round	3,3048	1,3498	1,0000	7,0000
Time	103,3037	34,9212	38,0000	326,0000
Rankwght	173,9419	143,1194	3,0000	1161,0000
Rankdiff	80,5635	103,6715	1,0000	875,0000
Aces1	9,0231	6,5040	0,0000	49,0000
Dfs1	6,3374	4,0806	0,0000	36,0000
Brkpts	14,7352	6,7950	1,0000	55,0000
Breaks	6,0150	2,9079	0,0000	23,0000
Points	161,4183	58,3941	60,0000	485,0000
Games	24,4079	7,6863	11,0000	58,0000
Ppg	6,5548	0,6361	3,6667	10,1053
Format	3,3002	0,7144	3,0000	5,0000
Field	54,2268	33,4783	32,0000	128,0000
Pdpurse	733,1756	803,7764	97,5000	2959,2800
Draw	58,0718	35,0428	32,0000	128,0000
Spread	23,4046	26,0933	3,3938	268,5060
Arankwgh	179,6471	59,2152	60,1290	332,8000
Mssteps	1,2889	0,0682	1,2411	1,4650

Note: n = 6715

Source: Authors' calculations from data provided by ATP Tour offices, 1995.

Variables that represent the effort level should perhaps be mentioned briefly. TIME variable ranges from 38 minutes to 326 minutes, or from about half-an-hour to about five hours and forty three minutes. It is most likely that later information comes from the match that had FORMAT 5. Average time it took to play a match during 1992 and 1993 ATP Tour was about two hours and twelve minutes. Variable GAMES shows a range from eleven games to fifty eight games, with a mean of about twenty four games. Minimum number of games should be 12 (6/0, 6/0), however minimum of eleven games reflects the default that occurred during a match, thus match was not finished. This is interesting information. We have some defaults in the matches in my data, but it seems that players default only when a large number of games have been played already, match result is close. This suggests that defaults are rather related to the player's injury than to a "giving-up" problem, which is accepted, for instance in chess games, but not in tennis. If we compare the means of time and games (103.304 minutes, 24 games), it turns out that it takes, on average, about 4 minutes per game. Minimum number of POINTS played in a match is 60, while maximum is 485, and the mean is about 161 points. If we compare average time of a match with the average number of points played in a match, it can be observed that it takes about 60 seconds per point, or 1 minute to complete a point. Even though these numbers are reasonable, comparing variables GAMES and POINTS to the variable TIME, results will however produce biased estimates since TIME variable consists of the total time it takes to complete a match, not the actual time it takes to complete a match, which is much shorter. For example, Pete Sampras defeated Goran Ivanisevic in the finals of '94 Wimbledon 7/6, 7/6, 6/4, and while the match lasted about two hours, time counted when ball was in play, or the actual time of play was only 8 minutes. Players do have 25 seconds break between the points and 90 seconds break at the changeover. Players played on average about seven points per game (PPG), with minimum of four points and maximum of 10 points per game.

PDPURSE, or a total prize available for the singles competition, has a mean of 733.1756, or $733, 175.6. Minimum purse offered for singles play was 97.500 or $97,500 and maximum purse offered was 2959.28 or $2,959,280. On the other hand, SPREAD level, or the marginal expected prize, has a mean of $23,404. The lowest SPREAD is equal to $3,393.75, and the highest SPREAD available is equal to $268,506.

Table 2 illustrates descriptive statistics at the tournament level. This information is thus based on the 168 tournaments.

Variable BYES represents direct advancement into the second round without play, usually given to seeded players. Maximum number of byes assigned in the sample of tournaments was 32. It is interesting to point out that total number of double faults across tournaments is lower, on average, than the total number of aces.

Table 2: Descriptive statistics from tournaments' generated data

Variable	Mean	Standard Deviation	Minimum	Maximum
Byes	2,7797	5,8926	0,0000	32,0000
Field	42,1726	22,2538	32,0000	128,0000
Pdpurse	471,4829	544,5654	97,5000	2959,2800
Draw	44,9523	24,8412	32,0000	128,0000
Rankwght	6952,5000	3779,6600	1812,0000	22839,0000
Rankdiff	3220,1400	1956,3800	932,0000	12331,0000
Aces	360,6547	333,0848	93,0000	2217,0000
Dfs	261,9960	153,8394	163,3025	907,4551
Brkpts	200,8630	169,2468	91,0000	1082,0000
Breaks	240,4226	192,0514	114,0000	1219,0000
Points	6451,9300	5720,4000	3710,0000	33153,0000
Games	975,5892	806,5902	571,0000	4597,0000
Arankwgh	179,6471	59,2152	60,1290	332,8000
Mssteps	1,2289	0,0681	1,2410	1,4650

Note: n = 168

Source: Authors' calculations from data provided by ATP Tour offices, 1995.

This result, perhaps, explains the quality of players involved in the professional tournaments.

5.1. Test of hypothesis 1

First hypothesis says, spread level is increasing at the constant (linear) or increasing rate as the number of rounds left to be played decreases, and in the final round, spread level should have a distinct jump from lower rounds' spreads. Theory suggests that amount of increase in spread will depend on the players' risk preference. If the participants are risk neutral a constant spread is sufficient from second place down, or up to the finals, while in the finals, a larger interrank spread is required. If the participants are risk averse, the spread level should be increasing at an increasing rate with an even larger increment between first and second place. As Rosen points out, the spread has to be increasing to "buy off "survivor's risk aversion and maintain their interest in advancing to higher ranks (1986). By observing following tables we see that the structure of spreads and prizes in professional tennis tournaments does not perfectly fit into the theory. To make things easier, we created two tables, which show percentage differences between means of different spreads and prizes for 32, 64, and 128 draws.

Table 3: Means and percentage differences between means for $SPREAD_i$

Variable	Mean32	% Δ	Mean64	% Δ	Mean128	% Δ
SPREAD1					22,3920	
SPREAD2			16,3200		36,9880	39,4600
SPREAD3	8,9610		26,4160	38,2222	61,1710	39,5300
SPREAD4	13,2610	32,4300	41,0490	35,6400	98,2340	37,7300
SPREAD5	18,2810	27,4600	59,5090	31,0200	147,5680	33,4300
SPREAD6	22,3830	18,3333	76,9000	22,6100	198,9380	25,8200
SPREAD7	20,7040	8,1000	74,6260	3,0500	197,8340	0,5600

Note: i = 1,...,7., and DRAW = 32, 64, 128
Mean32 stands for the means where DRAW = 32; Mean64 stands for the means where DRAW = 64; Mean128 stands for the means where DRAW = 128.

Source: Authors' calculations from data provided by ATP Tour, 1995.

Table 4: Means and percentage differences between means for $PRZDIF_i$

Variable	Mean32	% Δ	Mean64	% Δ	Mean128	% Δ
PRIZDIF1					3,8977	
PRIZDIF2			3,1111		6,4403	39,1300
PRIZDIF3	2,3310		5,8920	47,1900	12,0540	46,8800
PRIZDIF4	4,1210	43,4400	11,2940	47,8300	24,4490	50,7000
PRIZDIF5	7,0890	41,8700	21,0590	46,3700	48,0990	49,1700
PRIZDIF6	12,0310	41,0700	39,5870	46,8000	100,0210	51,9100
PRIZDIF7	20,7050	41,8900	74,6260	46,9500	197,8340	49,4400

Note: i = 1,...,7., and DRAW = 32, 64, 128
Mean32 stands for the means where DRAW = 32; Mean64 stands for the means where DRAW = 64; Means128 stands for the means where DRAW = 128.

Source: Authors' calculations from data provided by ATP Tour, 1995.

From table 3 we can conclude the following. First, the spread level between the rounds increases, but at a decreasing rate. By observing columns 3, 5, and 7 in table 3, % change between spread levels decreases. The largest spread effect is in the first rounds of the tournaments, and thereafter diminishes. Usually, purse amount is highly and positively correlated with the size of the draw, bigger draw, larger total purse, but holding the total purse constant, the percent change between the spread levels in a 32-draw tournament decreases faster than in the 64-draw tournament, than in the 128-draw tournament. Second, in all three tournament settings (32, 64, and 128) the final interrank spread drops. Thus the percentage change in the final spread level, between a finalist's and winner's payoff has a negative sign. The final spread is actually lower than the previous one.

From table 4 results are somewhat different. This table observes changes between prize levels instead of spreads per round. Again, in 32-draw tournaments first round provides the largest percent difference between prizes. For the 64-draw tournaments the largest percent difference occurs in the second round. In the case of the 128-draw tournaments, largest percent change occurs in the third round and again in the semi-finals. Second, by observing columns 3, 5, and 7 it is easy to notice a relative linear increase between prize levels. Thus, $PRIZDIF_i$ increases at the constant rate throughout a tournament. Only a small drop in the difference of prize levels is noticeable in the final round of 128-draw tournaments, however insignificant.

Figures 1 and 2 represent the results from tables 3 and 4. Figure 1 shows the relationship between spread levels and the percent change among them over seven rounds of a tournament. As the figure illustrates, $SPREAD_i$ for all three types of tournaments increases at the decreasing rate up to the final round and than it drops. Percentage change among $SPREAD_i$ throughout a tournament for all three types of tournaments shows more significantly this negative trend between spread levels. Figure 2 illustrates a trend for $PRZDIF_i$ and percentage change between $PRZDIF_i$ across tournament rounds. Changes between $PRIZDIF_i$ are rather linear across the rounds for all three types of tournaments. From percentage changes among $PRZDIF_i$ it is obvious that level of difference in the final round does not have a distinctive jump, on the contrary, it drops somewhat.

From the above tables and figures 1 and 2 all the results point toward rejecting the first hypothesis. Most of the empirical papers did not test this proposition, thus it is impossible to compare my results with other findings. However, spread level in Rosen's sense, and even the prize level, is not structured in a way that satisfies theoretical claims. Major deviation from the theory, in my opinion, is the result we obtain from tables and figure 1 on the final interrank spread. It does not show any distinct increase, on the contrary, it drops. Under this circumstance we should expect to see the lowest amount of effort supplied in the finals, since spread level is not set in a way to make a tournament a non-ending game. Expected payoff, under current conditions, decreases as the number of rounds left to be played decreases. We can think of two possible reasons that explain this tournament setting. First, purse level and at the same time, prize levels increased by more than 15% since ATP Tour started to run the Tour in 1990. This increase in money was even higher in 1992 and 1993, years of our data set, comparing it to 1989, last year Tour was run by the International Tennis Federation. Thus, an increase in earnings caused an increase in entry of good players, supply curve of professional player's shifts to the right, and, on the other hand, current players in order to successfully compete and earn higher available rents, needed to improve their game. Cost associated with effort level did increase as well as the benefits associated with higher prizes. With that in mind, players' responsiveness to the different spread levels might not be as elastic as it was prior to 1990. We can argue that new entrants are young players who are less responsive to spread, and even though spreads are not increasing at some constant rate, they are motivated to compete because winning increases their total earnings. On the other hand, older players will have to compete hard to be able to maintain their ranking. Second hypothesis will address the issue of spread and effort level in a more detailed fashion. Second reason for this anomaly, larger spread in the semi-finals than in the finals, could be associated with the reputation effect. Once players reach a final round, winning a title earns them more than just prize money. They also obtain a certain level of utility from wining a title, which is the goal of their profession, ATP Tour points, which help increase their ranking, bonuses on their endorsement deals and new endorsement deals, invitations for exhibition matches, and other pecuniary benefits. Including all of these benefits, which posses the monetary value and certainly complement the prize earnings, they perhaps offset the low spread in the finals. The problem with this argument is that a drop in the spread in the final round could be understandable for a tournament like Wimbledon, which is perhaps the most popular tournament among public. But, observing table 3, columns 3 and 7, which compare percentage difference among spreads between small tournaments (32 draw) and Majors (128 draw) we can see that small tournaments provide lower percentage change among different spreads, and in the final round, spread drops at the larger rate than is the case with large tournaments. It is hard to assume that winning a small tournament provides higher level utility (reputation) for a player vis-à-vis winning a Major tournament. Opposite result than the one from table 3 would be more reasonable. In small tournaments, DRAW = 32, some players receive guarantees to show-up and play. Dollar amount of these guarantees is not publicly available, but it is known that many times that amount is larger than the amount of money winner of the tournament receives. Perhaps, small tournament can offer small spread in the final round, since they have other means of securing good players. On the other hand, it is in players' interest to perform well, or, in the long-run, benefits associated with marquee name will vanish. However, the fact is that players gain more than just the prize money by winning a tournament or finishing very high. Again, test of second hypothesis will answer more on questions related to spread and effort level.

5.2. Test of hypothesis 2

Hypothesis 2 states that in the tennis tournaments top four ranks receive about 50% of total purse available. In other words, two semifinalists, finalist and a winner should receive about half of the total purse in prize money. This statement just supplements the assumption that spread level should increase as someone advances to the final two rounds, otherwise disincentive may prevail in a tournament setting.

We looked at the top three prize levels, winner, finalist, and 2 semifinalists, and compared their earnings to the total tournament purse. Tournament's purse depends not only on the DRAW size, but also on the FIELD. I created means of prizes for 32, 48, 53, 56, 64, 96, and 128 FIELD tournaments. By adding up top three prizes and dividing them by the PDPURSE, we got the percentage of earnings for the top four ranks. Tables 5 and 6 summarize the information needed.

Table 5: Means, PDPURSE, and %TPDPURSE for tournaments

Variable	Mean32	Mean48	Mean53	Mean56	Mean64
PRIZE1	*49.6950*	*155.1286*	*152.0000*	*157.4762*	*209.8500*
PRIZE2	*28.9900*	*83.5964*	*80.5000*	*83.0121*	*110.3000*
PRIZE3	*16.9588*	*45.0321*	*42.5000*	*43.8629*	*58.1525*
PRIZE4	9.8696	24.3964	22.5000	23.0881	30.6050
PRIZE5	6.7487	12.8486	11.7500	12.2374	16.1485
PRIZE6	5.3410	7.0421	6.2000	6.4338	8.5550
PRIZE7	0.0000	3.9250	3.2000	3.4036	4.5700
PRIZE8	0.0000	0.0000	0.0000	0.0000	0.0000
PDPURSE	*252.7589*	*704.6379*	*667.9000*	*703.0921*	*971.1830*
%TPDPURSE	*37.8400*	*40.2700*	*41.1700*	*40.4400*	*38.9500*

Note: FIELD = 32, 48, 53, 56, 64., and n = 120, 14, 1, 21, 2
Mean32 stands for prize level means when FIELD = 32; Mean48 stands for prize level means when FIELD = 48, Mean53 stands for prize level means when FIELD = 53; Mean56 stands for prize level means when FIELD = 56; and Mean64 stands for prize level means when FIELD = 64. %TPDPURSE stands for the percent of total purse under different FIELDs.

Source: Authors' calculations from data provided by ATP Tour, 1995.

Table 6: Means, %TPDPURSE, and PDPURSE

Variable	Mean96	Mean128
PRIZE1	*202,9500*	*447,4933*
PRIZE2	*106,7650*	*224,2460*
PRIZE3	*56,1500*	*111,8730*
PRIZE4	29,5475	58,3993
PRIZE5	15,5300	31,3416
PRIZE6	8,1750	18,1123
PRIZE7	4,3550	11,0635
PRIZE8	2,3100	6,7026
PDPURSE	*1008,5300*	*2452,6100*
%TPDPURSE	*36,2800*	*31,9500*

Note: FORMAT = 96 and 128, and n = 2 and 8
Mean96 stands for means of prizes when FORMAT = 96; Mean128 stands for means of prizes when FORMAT = 128; %TPDPURSE stands for percent of PDPURSE for different FIELDS.

Source: Authors' calculations from data provided by ATP Tour, 1995.

From tables 5 and 6, it is easy to observe that top four ranked players in tournaments organized by the ATP do not receive around 50% of the total purse. Actually, they receive much less. Most of the tournaments under different FORMATS offer around 40% of the total purse to the last four players left in the tournament, two semifinalists, one finalist, and one winner. It is interesting to see that in tournaments where FORMAT = 128, table 6, last four players left in the tournament receive less in terms of the percentage of the total purse than in any other FORMAT tournament. Tournaments where FORMAT = 53 offer the largest percentage of total purse to the top 4 performers left in a tournament, 41.17%. Thus, results point to rejection of hypothesis 2. Professional tennis tournaments are not structured according to Rosen's theory, and we will present later if current tournament structure affects the quality of play, and ultimately the profits of tournament owners (organizers). Similar arguments could be applied in this section as they were applied in the previous section. If we observe high effort level under current tournament setting, we should conclude that players' performance and effort level that they supply during play depends on more variables than just the spread level. Perhaps other pecuniary benefits are important as well.

5.3. Test of hypothesis 3

Third hypothesis states that as the spread level increases, effort level provided by the players will increase. Empirical results from sport arenas show that increase in prize money available for a certain place will induce individuals to perform better, they will run faster, shot lower score on the golf field, race cars faster, and so on. A player's decision on how much effort he is willing to supply will depend on marginal benefits he will obtain vis-à-vis marginal costs. However, the amount of effort he will need to supply will depend on his ability and the ability of his possible opponents. Another complication is associated with value of advancing, which depends on how the player assesses future effort should eligibility be maintained. According to Rosen, the value of maintaining eligibility at any stage is the sure prize the player has guaranteed by surviving that long, plus the discounted sum of successive inter-rank rewards that may be achieved in future matches (1986). This is what we call a spread. Given the spread, every player will decide on his optimal effort level in order to maximize the utility. Output function will also depend on the ability of the players that he may confront during a tournament, and his own current form. Finally, effort level will be influenced by what Nalebuff and Stiglitz call, an environmental variable. In tennis tournaments environmental variable could represent the surface on which the tournament is held, or the format of the match, is it best of three sets or best of five sets match. Thus, in particular, we can write the equation that represents second hypothesis as:

$$\mu_{ji} = f\ \{[W_{is} - W_{i(s+1)}], \gamma_{ji}, \gamma_{jo}\} + \theta_i + \varepsilon_{ji} \qquad (1).$$

Here μ_{ji} stands for pair of individuals js' score in a match i, W_{is} - $W_{i(s+1)}$ stands for the spread, or the marginal reward for advancing one place in the final ranking in a match i where the number of stages remaining to be played is s. γ_{ji} and γ_{jo} are measures of the player's own ability and his competitor's ability, θ_i reflects the tournament specific factors, like format and surface, and ε_{ji} is a random error term. First variable we used to estimate the effort level is variable TIME. From equation (1) we constructed the following regression:

$$TIME_{ji} = \alpha_0 + \alpha_1 SPREAD_i + \alpha_2 RANKWGHT + \alpha_3 RANKDIFF + \\ + \alpha_4 SURFACE_i + \alpha_5 FORMAT_i + \eta_j \quad (2).$$

$TIME_{ji}$ measures the time of the match i between a pair of players j in minutes. $SPREAD_i$ measures the marginal reward for advancing one place in the final ranking in a match i, RANKWGHT measures the level of the ability present in the matches, and it is derived as the summation of rankings among paired players. RANKDIFF is the absolute value of the difference in a ranking between two players, which also measures the level of ability among pairs of players. $SURFACE_i$ stands for the type of surface matches are played on. There are four types of surface, carpet, clay, grass, and hard. These are constructed as dummy variables that take on values 0 or 1. Base variable is hard. Variable $FORMAT_i$ reflects to the type of the scoring system, two out of three sets or best of three (3), and three out of five sets, or best of five (5). $FORMAT_i$ is also constructed as the dummy variable that takes on values 0 and 1. Base is best of five (5) matches. Results in table 7 also include the same regression as (1), but one of the independent variables is $PRZDIFF_i$. $PRZDIFF_i$ measures only the numerical difference between two prizes. Thus,

$$TIME_{ji} = \alpha_0 + \alpha_1 PRZDIFF_i + \alpha_2 RANKWGHT + \alpha_3 RANKDIFF + \\ + \alpha_4 SURFACE_i + \alpha_5 FORMAT_i + \eta_{ij} \quad (3).$$

Let us focus our attention to the table XV.

Table 7, column (1) presents estimates of the equation (2). As the spread level increases, time of the match increases as well. If time is some accurate proxy for the effort level, this finding supports theory based on tournament model. For every increase in spread, for let say \$100, time of the match goes up by 6 minutes. We can also see that if the difference in ranking among pairs of players increases, matches will last shorter time period, which is reasonable since it is expected that better players beat lower ranked players faster. On the other hand, as the RANKWGHT increases, time of the match will last longer. Again, RANKWGHT measures the quality of the draw, the quality of participants in a tournament. Better players will have higher ranking, which in turn means lower numerical position, number 1, number 2, and so on. Thus, as the number on RANKWGHT gets lower, higher ranked players are participating, and the opposite, as the number gets higher, lower ranked players are participating.

Table 7: Effort level equations for the 1992-93 ATP Tour

Variable	(1)		(2)	
Intercept	148,4903	(63,3700)	150,4650	(74,7200)
SURFACE				
Carpet	-0,6942	(0,5300)	-0,5085	(0,3900)
Clay	4,4711	(4,3700)	4,3727	(4,2800)
Grass	6,5170	(0,3580)	-6,6083	(3,6300)
Hard				
FORMAT				
3	.51.5508	(26,6500)	-52,7438	(29,2900)
5				
RANKWGHT	0,0132	(2,4500)	0,0115	(2,1800)
RANKDIFF	-0,0280	(3,9200)	-0,0266	(3,7600)
SPREAD	0,0607	(2,6600)		
PRZDIFF			0,0896	(2,2800)
R2 (1)	0,1679			
R2 (2)			0,1675	
F value	149,5000		149,1700	
n	5195,0000		5195,0000	

Note: Dependent variable = Time. Statistics are derived from match play in a tournament. Absolute value t-statistics in parentheses.
SURFACE: Hard = 0, otherwise 1.
FORMAT: 5 = 0, otherwise 1.
RANKWGHT: Σ ($rank_i$ + $rank_o$) where i stands for one player and o for his opponent in a match.
RANKDIFF: |$rank_i$ - $rank_o$| where i and o stand for a pair of players in a match.
SPREAD: marginal expected prize for winning in a round i, where i = 1,..., 7.
PRZDIFF: difference between two prizes in round i, where i = 1,..., 7.
R sq. values are adjusted for d.o.f.

Source: Authors' calculations from data provided by the ATP Tour, 1995.

Sign on the variable is positive and significant, thus we can only conclude that draws containing lower ranked players produce matches that last long time. This can be true especially in tournaments with smaller purse where only a small number of top players enter, and even though they win fast, majority of matches takes longer time to complete since lower ranked but even in the ability players confront each other. Matches played under format 5 and on the hard surface last longer in general than matches played under format 3 on the hard surface. Only matches that are played on the clay surface last longer than on the hard surface.

Table 7, column (2) presents estimates of the equation (3). Signs in column (2) do not differ from the signs in column (1). Most of the results are very close. Again we see that effort level also depends on the difference in prizes by round (PRZDIFF) as well as it was the case with variable spread. As the difference in two prizes increase by $100, time of the match increases by about 9 minutes. Under the SPREAD variable this increase is lower, which could possible suggest that players are more sensitive to immediate reward, they look only at the current payoff instead of all the future possible payoffs.

Table 8 offers three new equations similar to the equation (2), but with different dependent variables. Table 8 includes three dependent variables, which should proxy the effort level, GAMES, POINTS, and PPG. Regressions from table 8 are derived from the same equation as (2) except different dependent variable was used. For instance, PPG_i measures the number of games played in a game in match i. We assume more effort is supplied, and more entertaining match will be as the number of games or points is played, since it makes the match closer.

Table 8: Effort level equations for the 1992-93 ATP Tour

Variable (dependent)	GAMES		POINTS		PPG	
(independent)	(1)		(2)		(3)	
Intercept	34,8674	(116,1300)	242,7574	(108,8700)	6,9368	(231,9800)
SURFACE						
Carpet	0,6842	(3,0100)	3,0740	(1,8200)	-0,0508	(2,2500)
Clay	-0,2005	(1,1600)	-0,0402	(0,0300)	0,0605	(3,5200)
Grass	10,7400	(3,7600)	8,2989	(3,9200)	0,0133	(0,4700)
Hard						
FORMAT						
3	-12,6474	(52,5400)	-99,3288	(55,5556)	-0,4980	(20,7700)
5						
RANKWGHT	0,0018	(1,9800)	0,0165	(2,4444)	0,0002	(2,5300)
RANKDIFF	-0,0044	(3,6100)	-0,0345	(3,8300)	-0,0003	(2,6400)
SPREAD	0,0072	(2,1400)	0,0673	(2,6800)	0,0005	(1,4900)
R2	0,3710		0,3989		0,0892	
F value	565,1000		635,9000		93,8500	
n	6714,0000		6714,0000		6714,0000	

Note: Dependent variables are 1. GAMESi, 2. POINTSi, 3. PPGi. Statistics are derived for match play in a tournament. Absolute value t-statistics in parentheses. Gamesi: total number of games played in a match i.
$Points_i$: total number of points played in a match i.
Ppg_i: total number of points per game played in a match i.
R-sq. adjusted for d.o.f.

Source: Authors' calculations from data provided by the ATP Tour, 1995.

Column (1) in table 8 provides us with estimates using variable GAMES as a dependent variable. We can see again that variable SPREAD is positive and significant. For every increase in spread by $1,000 players play additional 7 games, or the matches get closer, in a sense. Matches played in the best of five format on hard courts last longer than matches played in the best of three format on same type of surface. It is interesting to point that matches played on grass and carpet last longer, holding other things constant, than matches played on the clay surface. T-statistic on surface clay is not significant. This is true for both formats. One possible explanation for this is that it is much easier to win own service game on fast surfaces like carpet or grass than on a slow surface like clay. Therefore, we observe a fact that more games are played on faster surfaces, but also from table 7, that matches played on fast surfaces last shorter period of time. Difference in ranking variable has a negative sign and it is significant. As the difference in ranking between two players increases, lower number of games is played. For example, for an increase of 100 in absolute ranking difference, 0.4 or almost 1 game is played less. Variable representing the level of the ability among players, RANKWGHT, has positive sign and significant coefficient. As the ranking decreases among the players, number of games played decreases as well. We found this result to be consistent with the result from table 7. Thus, under the assumption that GAMES proxy some effort level efficiently, not necessarily will draws filled with high ranked players produce matches that result in a large number of games, and perhaps more entertaining.

Column (2) from table 8 shows regression estimates using POINTS, total number of points played in a match i, as a dependent variable. Column (2) produces similar results as column (1). If we increase the spread by $100, number of points played in a match increases by 6. Even though variable clay is insignificant, sign points out that more points is played on faster surfaces. We should take this statement with caution since variable carpet is not very significant, and perhaps variable POINTS is affected by the total number of games played. If we focus our attention to the column (3) where dependent variable is PPG, points per game, we can see that actually more points per game is played on clay than any other surface. The strange result from column (2) is that just less games is played on clay, and thus less points. Spread variable does not result in a significant t-statistic; however, it shows that for an increase of $10,000 in spread there will be an increase of 5 points per game. Other results are consistent with results from columns (1) and (2).

Table 9 illustrates the regressions using variables ACES, BRKPTS, and BREAKS as dependent variables. Again, variable BRKPTS was constructed in a way to measure both players output. This was not done for the variable ACES, since even if one player serves hard, we assume that he is doing that because his opponent is tough as well. Also, some players are better returners of the serve than their opponents, which will reduce the number of aces for the opponent who still tries hard. Regressions presented in table 9 were derived from the same equation like (1) using different dependent variables.

Table 9: Effort level equations for the 1992-93 ATP Tour

Variable (dependent)	ACES		BREAKPTS		BREAKS	
(independent)	(1)		(2)		(3)	
Intercept	12,6582	(45,2600)	7,6250	(47,1200)	8,3783	(64,2100)
SURFACE						
Carpet	3,4528	(16,3300)	0,4947	(4,0400)	0,7934	(8,0500)
Clay	-2,8862	(17,9800)	0,5745	(6,1900)	0,8808	(11,7600)
Grass	2,7950	(10,5100)	-1,0878	(7,0700)	-1,1685	(9,4200)
Hard						
FORMAT						
3	-12,6474	(52,5400)	-99,3288	(55,5556)	-0,4980	(20,7700)
5						
RANKWGHT	-0,0026	(3,1100)	0,0020	(3,9900)	0,0019	(4,7200)
RANKDIFF	0,0004	(0,3100)	-0,0033	(5,1200)	-0,0016	(3,0300)
SPREAD	0,0274	(8,7000)	-0,0058	(3,1900)	-0,0046	(3,1300)
R2	0,2377		0,1021		0,1701	
F value	298,8100		108,9800		196,4400	
n	6714,0000		6714,0000		6714,0000	

Note: Dependent variables are 1. ACES, 2. BRKPTS, 3. BREAKS. Statistics are derived from match play in a tournament. Absolute value t-statistics in parentheses.
Aces: total number of aces served either on the first or the second serve in the match.
Brkpts: total number of paired break points in a match.
Breaks: total number of converted break points into a game.
R square adjusted for d.o.f.

Source: Authors' calculations from data provided by the ATP Tour, 1995.

Table 9, column (1) are illustrating results from the regression (2) where ACES is the dependent variable. If number of ACES in a match measure effort level by two players, it is strongly dependent on the variable SPREAD. For an increase of $1000 in spread, number of aces served in a match increases by 27 aces. Column (2) of the table 9 presents regression where number of paired break points is a dependable variable, BRKPTS. SPREAD is significant and it has negative coefficient. This implies that as the level of spread increases, players earn lower number of break opportunities. We have seen from column (1) that the number of aces increases as the spread level increases, which in a sense supports the above statement that as the spread level increases players play much harder on their serve, and we see less breaks. This is telling us, also, that good returns will be crucial in winning matches where spreads are very high. Regression using dependent variable BREAKS, in column (3), gives similar results as column (2). Coefficients on the variables that proxy ability level are consistent with column (2).

From the above regressions, tables 7, 8, and 9, results are significantly and consistently pointing toward accepting the second hypothesis. We conclude that spread level will positively influence players to supply effort in professional tennis tournaments. This finding is consistent with other findings derived from analysis using sport data.

6. Conclusion and extension

We focused in this paper on two major issues: 1. does the level of spread matter in determining the efficient amount of effort supplied, and 2. we looked into the structure of spreads among professional tennis tournaments and analyzed it along the lines of theoretical work.

We found that spread level in a tennis tournament on the ATP Tour is not structured in the efficient way as the tournament theory would suggest. Basically, spread level increases at the decreasing rate, and the amount devoted for the final spread decreases in percentage terms, instead the opposite. Both findings contradict the theory. However, even though poorly structured, changes in spread level in ATP Tour tournaments do cause direct changes in the effort level supplied by the players. As the spread increases we see players trying harder.

This is just a marginal contribution to a relatively small literature available regarding tournament analysis. Trying to understand how to obtain and manipulate data from the firm's labor environment should be a major concern and task of the future research.

References

Antle, R., Smith, A., (1990) "Does Performance-Based Managerial Compensation Affect Corporate Performance?" *Industrial and Labor Relations Review*, Vol. 43, February, pp. 52S-73S.

Akerlof, G., (1976) "The Economics of Caste of the Rat Race and other Woeful Tales," *Quarterly Journal of Economics*, Vol. 90, pp. 599-617.

Alchian, A., (1988) "Promotions, Elections and Other Contests; Comment," *Journal of Institutional and Theoretical Economics*, Vol. 144, January, pp. 91-93.

Becker, B. E., Huselid, M. A., (1992) “The Incentive Effects of Tournament Compensation Systems,” *Administrative Science Quarterly*, Vol. 37, June, pp. 336-350.

Bronars, S., (1987) “Strategic Behavior in Tournaments,” Manuscript, January.

Bull, C., Schotter, A., Weigelt, K., (1987) “Tournaments and Piece Rates: An Experimental Study,” *Journal of Political Economy*, Vol. 95, no. 1, pp. 1-33.

Collins, B., (1994) *Modern Encyclopedia of Tennis*, Detroit: Visible Ink Press.

Doherty, D., (1990) “Here They Go! The Men Launch the ATP Tour,” *Tennis*, January, pp. 40-45.

Dye, R. A., (1984) “The Trouble with Tournaments,” *Economic Inquiry*, Vol. 22, January, pp. 147-149.

Ehrenberg, R. G., Bognanno, M. L., (1990) “Do Tournaments Have Incentive Effects?” *Journal of Political Economy*, Vol. 98, no. 6, pp. 1307-1324.

--- (1990) “The Incentive Effects of Tournaments Revisited: Evidence From the European PGA Tour,” *Industrial and Labor Relations Review*, Vol. 43, February, pp. 74S-88S.

Fama, E. F., (1991) “Time, Salary, and Incentive Payoffs in Labor Contracts,” *Journal of Labor Economics*, Vol. 9, no. 1, pp. 25-44.

Flink, S., (1994) “Tournament Directors-Serving and Surviving,” *Tennis Week*, April, pp. 26-28.

--- (1994) “Guaranteed Controversy-Do Guarantees Corrupt the Tour?” *Tennis Week*, November, pp. 18-20.

--- (1994) “ITF vs. ATP-Rankings Rankle,” *Tennis Week*, July, pp. 8-9.

--- (1993) “Fernberger on the State of the Game,” *Tennis Week*, March, pp. 8-9.

Gibbons, R., (1987) “Piece-Rate Incentive Schemes,” *Journal of Labor Economics*, Vol. 5, no. 4, pp. 413-429.

Gibbons, R., Murphy, K., (1990) “Relative Performance Evaluation for Chief Executive Officers,” *Industrial and Labor Relations Review*, Vol. 43, February, pp. 30S-51S.

Goff, B. L., Tollison, R. D., (1990) *Sportometrics*, College Station: Texas A & M University Press.

Green, J. R., Stokey, N. L., (1983) “A Comparison of Tournaments and Contracts,” *Journal of Political Economy*, Vol. 91, no. 3, pp. 349-364.

Hackney, H., (1990) “Country Club Ethics,” *FW*, September, pp. 52-54.

Jensen, M. C., Murphy, K.J., (1990) “Performance Pay and Top-Management Incentives,” *Journal of Political Economy*, Vol. 98, no. 2, pp. 225-264.

Knoeber, C. R., Thurman, W. N., (1994) “Testing the Theory of Tournaments: An Empirical Analysis of Broiler Production,” *Journal of Labor Economics*, Vol. 12, no. 2, pp. 155-179.

Lazear, P. E., (1989) "Pay Equality and Industrial Politics," *Journal of Political Economy*, Vol. 97, June, pp. 561-80.

Lazear, P. E., Rosen, S., (1981) "Rank-Order Tournaments as Optimum Labor Contracts," *Journal of Political Economy*, Vol. 89, no. 5, pp. 841-864.

Lorge, B., (1990) "Hamilton Jordan, The Man Who Made it Happen," *Tennis*, January, pp. 47-51.

Main, B. G. M., O'Reilly III, C. A., Wade, J., (1993) "Top Executive Pay: Tournament or Teamwork?" *Journal of Labor Economics*, Vol. 11, no. 4, pp. 606-628.

Maloney, M. T., McCormick, R. E., (1994) "The Response of Workers to Wages in Tournaments: Evidence from Foot Races," Manuscript, January.

McLaughlin, K. J., (1988) "Aspects of Tournament Models: A Survey" *Research in Labor Economics*, Vol. 9, pp. 225-256.

Miles, M., (1992) "The ATP Tour: We are the World," *Tennis*, October, pp. 19.

Nalebuff, B. J., Stiglitz, J. E., (1983) "Prizes and Incentives: Towards a General Theory of Compensation and Competition," *Bell Journal of Economics*, Vol. 14, Spring, pp. 21-43.

O'Keeffe, M., Viscusi, W. K., Zeckhauser, R. J., (1984) "Economic Contests: Comparative Reward Schemes," *Journal of Labor Economics*, Vol. 2, no. 1, pp. 27-56.

Pentz, L., (1994) "The State of the Game," *Tennis Week*, February, pp. 12-14.

--- (1994) "Best 14 and its Worst of Times," *Tennis Week*, October, pp. 18-19.

Rosen, S., (1986) "Prizes and Incentives in Elimination Tournaments," *The American Economic Review*, Vol. 76, no. 4, September, pp. 701-715.

--- (1981) "The Economics of Superstars," *The American Economic Review*, Vol. 71, no. 5, December, pp. 845-858.

--- (1988) "Promotions, Elections and Other Contests," *Journal of Institutional and Theoretical Economics*, Vol. 144, January, pp. 73-90.

Schlicht, E., (1986) "Promotions, Elections, and Other Contests," *Journal of Institutional and Theoretical Economics*, Vol. 144, January, pp. 94-99.

Scully, G. W. (1992) *Advances in the Economics of Sport*, Vol.1, London: JAI Press Inc.

Vach, R., (1992) "Best 14 Rankings: Still Encouraging Players To Play," *International Tennis*, February, pp. 18-19.

Welling, B., (1988) "The Wrestling Match Over Men's Pro Tennis," *Business Week*, October, pp. 46-49.

Williams, R. M., (1991) "ATP Tour-The Good, The Bad & The Unclear," *Tennis*, February, pp. 49-50.

Turnir Model: Statistička investigacija ATP

Miren Ivankovic[1]

Sažetak

U konkurentnim tržištima, radna snaga plaćena je prema vrijednosti svoga rada. Ali kad usporedimo plaće visoko pozicioniranih menadžera, razlike u plaćama vrlo su velike. Svakako da su razlike u naknadama potrebne da bi se dao poticaj za postizanje najboljih rezultata od samog početka građenja menadžerske karijere. Međutim, struktura novčanih nagrada prema postignutim rezultatima u profesionalnom teniskom turniru ne korespondira teoriji turnira. Raspodjela novčanih nagrada prema rezultatima raste, ali po padajućoj stopi, te tako u finalnom kolu, visina novčane nagrade se smanjuje. Postotak promjene u visini novčane nagrade veći je u polufinalu nego li u finalu. U skladu s tim, četiri vrhunska teniska igrača u završnom kolu dobivaju samo 40% umjesto najmanje 50% od ukupnog fonda nagrada. Rezultati iz ekonometrijske radnje ukazuju na razlike u povezivanju rezultata rada s plaćama i ukupnim fondom nagrada. Međutim, rezultati nisu uvjerljivi, jer u nekim slučajevima, nagrađivanje truda statistički se temelji na ukupnom fondu nagrada umjesto na nagrađivanju prema postignutim rezultatima, dok se u drugim slučajevima temelji i na nagrađivanju prema postignutim rezultatima i raspodjeli ukupnog fonda nagrada, što je u suprotnosti s teorijama o turnirima.

Ključne riječi*: model turnira, plaće, trud, teniski turnir*

JEL klasifikacija*: J01*

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Appendix

Chart 1: Innterrank spread differences
Graf 1: Razlike u dodatnim novčanim nagradama za svako naredno polje

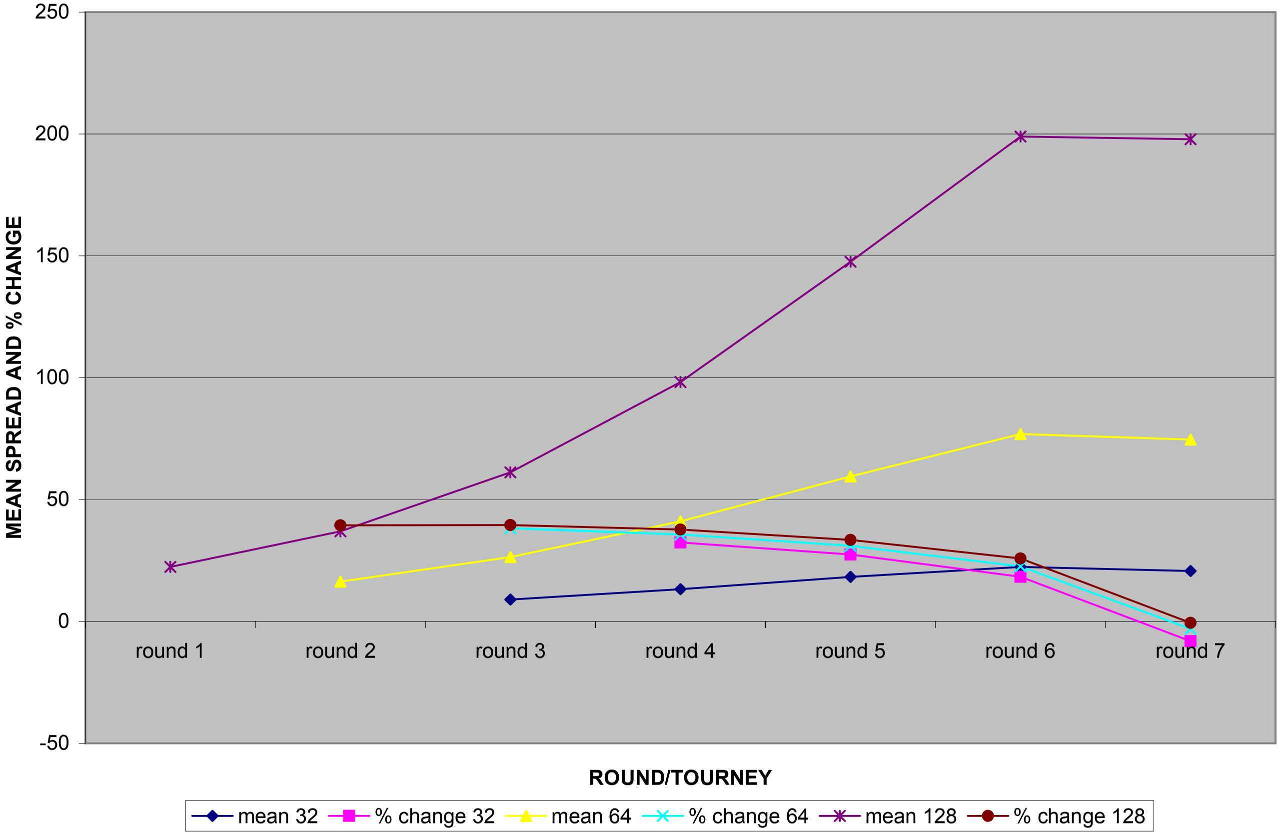

Chart 2: Innterrank prize differences
Graf 2: Razlike u novčanoj nagradi po odigranom kolu