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Incentives and Productivity in ATP Tournament Settings

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Abstract

Purpose: Tennis is long been identified as an excellent environment in which to test hypotheses emanating from Rosen's tournament theory. This paper develops a model explaining player productivity, defined as percent of match games won, by capturing more complete aspects of performance.
Materials and Methods: We employ five types of variables influencing match outcomes: (a) relative technical performance, (b) anthropometric measures, (c) experienced fatigue, (d) competitiveness, and (e) prize incentives. We test the model using ATP Tour statistics across tournaments with similar court characteristics—hard court surfaces—during the first few months of the 2010 tournament year.
Results: By testing the model on all players and then separately for match winners and losers, we identify how match productivity characteristics impact winning and losing differently. Although speculative at this stage, our research suggests that match success is also partially a function of factors not captured by our current model--factors such as match-up in players style of play, physical conditioning, tactical schemes, mental toughness, and sui generis external factors. However, the level of competitiveness emerges as a consistent and significant predictor of match productivity. Our study is one of the first utilizing raw match statistics to quantify players on-court performance. This enables us to (a) more completely understand the dynamics of player productivity in a specific tournament setting, (b) identify measures of relative technical performance, and (c) reveal the relative significance of the dynamics and technical performance to players' success on the court.
Conclusion: The results from the present study revealed that major determinants of the effort male professional tennis players put forth in matches they win are (a) mental toughness, (b) incentives, (c) own skills, (d) positive and negative events occurring in the major units (i.e., game) of a tennis match, and (e) quality of competition. Moreover, the level and quality of the effort put forth while in different playing circumstances (advantageous vs. disadvantageous position during a match) is determined by different factors.

Keywords: Effort, Incentives, Mental Performance, Psychology, Tennis, Tournament

Introduction

"It [tennis]'s a very mental game. People don't realize how much tension you have to go through throughout the match, ups and downs, highs and lows. And it's all part of the game. It's not easy" (Djokovic, 2010a). Professional athletes, however talented, face high psychological and physiological demands. Unlike team players, tennis professionals like athletes in other individual sports such as golf and bowling, must sustain their

effort and perform well enough to win several tournament rounds against multiple opponents, as well as contending with external factors (e.g., weather conditions, incentives, presence of spectators) that are not under the players' control. As a caveat of this research, we conducted an informal qualitative study of the press conference interviews given by the players of interest in the tournaments of interest for this study. Excerpts of the interviews are used throughout the paper for illustration purposes. In press conference interviews, top-ranked players have stressed on the demanding nature of the sport of tennis ("It definitely needs a special effort and a special sacrifice, and, you know, then you need some serious mental skills to handle the travelling and everything. It's not so easy. With different surfaces and injuries, it's demanding"(Federer, 2010a)) and the small differences in the skill level of top professional male tennis players ("Tennis is really getting close. All those guys [top-10 players] are pretty strong, so it's about just small, small things, small differences." (Berdych, 2010a)). Additionally, the players have accented on the fact that success in tennis is determined by one's ability to maintain optimal focus while facing distractions of various nature ("I think the biggest problem for me back in New York was obviously missing match points. But that goes without saying. I think I had too much of my mind focusing maybe already on the upcoming match I had to play the next day if I were to win. I think just mentally, … , I just think the short recovery time made it hard for both of us to focus on what we really had to do." (Federer, 2010b)) and exhibit mental toughness in the most important points during a tennis match ("… So, yeah, I mean, I was really mentally strong and calm when I needed to be. That was the key, I guess, in the second set." (Djokovich, 2010b)). The importance of sustaining mental toughness when experiencing momentum swing is captured in the following quote of Roger Federer:

"Then obviously it's a mental and sometimes physical battle in these best-of-three-set matches we play. But obviously momentum swings can be huge, you know, in these types of matches. So I mean, I don't know, I just try to give it all I have. And if, you know, you lose a set, it's not a problem, you know, because you still have a little bit of room to play with, you know. But it's bad, you know, losing the second one and then going into the third. You feel the momentum is on his side, and let's not get down on yourself. It's hard to stay positive, you know."(Federer, 2010c)

Empirical research has also shown that tennis players' performance is influenced by wide array of internal and external factors and one's ability to perform at an optimal level according to the demands of the situation is a requisite for success in tennis, as several researchers have applied Rosen's (1986) tournament model in tennis (Sunde, 2009; Gilsdorf and Sukhatme, 2008a, 2008b; Lallemand et al., 2008) to study players' response to incentives and heterogeneity. All of the aforementioned researchers have concluded that prizes do induce performance improvement. However, the researchers have come to inconsistent findings regarding the incentive effect of heterogeneity. It should be noted that in the aforementioned studies the researchers used rank difference between opponents and its derivatives as a measure of heterogeneity.

Despite the researchers' attempts to control for the insufficiencies of rankings as a measure of ability and previous findings that rank difference is a valuable predictor of the winner of a tennis match (Del Corral & Prieto-Rodriguez, 2010), still the utilization of this measure is questioned by others (McHale and Morton, 2011). In this study, we utilize three distinct measures of ability: (a) rank difference categories that count for the direction and magnitude of the rank difference (i.e., own player favorite/ underdog by a small or big margin); (b) opponent's current performance measured by the total service and return points won; and (c) own player's past performance measured by the win loss ratio on hard courts for the previous year.

Additionally, it appeared that most of the studies testing Rosen's (1986) tournament theory utilize a two-round contest. In this study, to count for the effect of the stages in a tournament, we use the number of ladders in a tournament. It should be noted that this specification has little or no overlap with other characteristics of a tournament (e.g., prize money, prestige). In other words, a low-level tournament (e.g., ATP World Tour 250) can have a 6-ladder structure while a high-level tournament can have a 5-ladder structure. Thus, it can be asserted that this measure counts solely for the number of stages/ participants one needs to overcome to win the grand prize.

In conclusion, when attempting to predict match outcomes and define tennis players' performance, researchers have used ex ante variables, with none utilizing the potential explanatory power of raw match statistics. The use of match statistics is challenging because it is not clear to what extent they accurately proxy player performance, or to what extent they are influenced by external factors such as weather conditions or even pure luck. Despite the obvious shortcomings of raw match data, we utilize their potential explanatory power to explicate further the psychological and relative competitive impacts on tennis match outcomes.

Even though previous empirical research has singled out some of the determinants of tennis players' performance, little research examines players' relative performance during a match or tournament. In attempt to address this lacunae, we examine professional male tennis players' behavioral response (i.e., effort put) to the dynamics of a tennis competition by counting for the influence of various internal and external aspects of his performance, such as technical ability, mental toughness and psychological skills, fitness level (through both body composition and experienced fatigue), tournament specifics and incentive structure.

Effort Allocation in Tournament Settings

While most tennis studies regard one's effort as constant during a match and tournament (Malueg and Yates, 2010; Sunde, 2009), others have suggested that contestants strategically allocate effort in accordance with the demands of the situation. Several researchers have acknowledged that the quality of past, current, and future opponents as well as the effort-cost ratio determine the effort exerted in a particular situation (Harbaugh and Klumpp, 2005; Rosen, 1986). In this study, we regard tennis players' effort as a dynamic process influenced by their ability to react and respond efficiently to positive and negative events throughout a game, set, and match. Additionally, it appears as though that players' performance in a tournament is influenced by their ability to overcome mental and physical fatigue due to tournament overload and travelling. For instance, Novak Djokovic stated:

"I mean, this is a tournament where I definitely didn't feel comfortable on the court. … It's just because I had a very tiring couple of weeks coming from Davis Cup, which was emotionally very exhausting for me. I had to travel the next day, you know, already, and came here, so I was not – I am not happy with the overall performance that I had in this tournament, because I know I could have played better and would have done better. But, look, you know, under decent circumstances I still made it to the fourth round, which is quite okay." (Djokovich, 2010c)

Interplay between Psychology and Economics

After reviewing several studies linking psychology and economics, we noted that depending on the leading perspective (i.e., psychological or economics) researchers have come to contradictory findings regarding similar matters. We discussed above that economists found that incentives play a major (positive) role in determining one's success on the court (Rosen, 1968, Sunde, 2009). In contrast, some psychologists find that incentives (e.g., monetary incentives, importance of success, and presence of audience) can have debilitative effect on one's athletic (Dohmen, 2008) and work performance (Ariely, 2009). In addition, researchers studying the effect of the "hot hand" phenomenon (i.e., success leads to success) have also arrived to contradictory findings. In a comprehensive review of the existing literature (prior to 2006), Bar-Eli et al (2006) found 11 studies that do not support the existence of hot hand, and 13 studies that do support the existence of this phenomenon in sports. They concluded that the presence of this phenomenon might be influenced by various factors (i.e., type of task, level of expertise, psychological factors).

For instance, Livingston (2012) found that the existence and the magnitude of the effects of the hot hand and the cold hand phenomenon in professional golf are determined by the players' level of expertise. That is, inexperienced male players are more likely to be affected by the hot hand and cold hand effects of their previous performances than more experienced players are. In tennis, Wozniak (2011) concluded that both male and female benefit from past successes; however, the duration of the effect differs for both genders. To elaborate, men experience the hot hand effect longer than women do. In addition to the thesis that the existence of the hot hand effect is mediated by various factors, McFall et al (2009) suggested that the observed inconsistency of previous research is because considerable part of the researchers utilized psychological framework (i.e., the effect manifests itself through one's confidence) in their studies. In their study, the researchers proposed and validated the application of economic framework (i.e., the effect manifests itself through inventive-induced motivation) for studying the matter in professional golf. That is, the winner in the first set in best-of-three matches will have a higher motivation to win the following set to avoid the possibility of having to play (additional) third set; thus, conserving effort.

In light of the aforementioned contradictory findings and possible gap between differing disciplinary interpretations of similar constructs, in this study, we utilize the construct of mental toughness to study the interplay of economics and psychology in professional tennis. Although sport psychology researchers have acknowledged that mental toughness does not have a clear definition yet, some of the prevailing attributes to mentally tough athletes are (a) ability to persevere and overcome adversity and failure (Weinberg et al., 2011), and (b) ability to cope with the competitive demands better than the opponent (Jones et al., 2002). In other words, mental toughness has been defined as a psychological edge that enables athletes consistently to react and respond to the psychological demands of their respective sports better than their opponents (Jones et al., 2002; Weinberg et al., 2011). Moreover, Weinberg et al (2011) have found that one's mental toughness manifests itself through psychological skills (e.g., maintaining focus and confidence), motivation to succeed (i.e., working hard), and resilience (e.g., bouncing back after failures and performing under pressure).

A further motivation for choosing the construct of mental toughness rather than the hot and cold hand effects is twofold. First, the two constructs differ when the role of the agent is considered. That is, when one experiences hot hand effect, he appears to be a passive agent, or the improvement in his performance is due to the experienced confidence built on previously experienced success. In contrast, mental toughness depicts more

active agency because it implies that athletes overcome adversity. Second, it is essential to underline the fact that the hot/ cold hand effect is a unidirectional construct, or only one's own (previous) performance is considered. In contrast, mental toughness (as per given definition) can be regarded as a two-directional construct, or it takes into account how one's own performance relates to the performance of the opponent. Given the fact that success in tennis is determined to great extent by the performance of the opponent, we assert that studying the effect of one's level of mental toughness would be more beneficial in unveiling the behavioral responses (i.e., effort put) of professional male tennis players to incentives and heterogeneity.

Data and Model Specifications

Data

To study the behavioral responses of top-ranked male tennis players to incentives and heterogeneity, we built an extensive dataset by collecting data from the official web site of the Association of Tennis Professionals (ATP) and ATP Tennis Navigator, software for tennis statistics. We studied the players who ranked in the Top 20 at the beginning of 2010 (as of January 4th, 2010). Table 1, Appendix A provides comprehensive information about the studied players. Table 2, Appendix B presents the specifics about the selected tournaments.

For our purposes, only the matches that a top-twenty player is a winner were used, which reduced the number of observations to 369. The reason to delimit the scope of the study only to the won matches is twofold: (a) to avoid possible dependence of the observations; that is, two top-twenty players face each other in a single match; and (b) to single out players' behavioral responses to incentives and heterogeneity in light of experienced success in a tennis match.

Model Specifications

To study the behavioral responses of top-ranked male tennis players to incentives and heterogeneity in tennis, we constructed two distinct models. The two models are identical except for the nature of the performance variable (explanation is provided below). The basic equations for the two models are:

Model A

$$P_{imj}=\beta_0+\beta_1 PSY_{imj}+\beta_2 pPER_{imj}+\beta_3 PRI_{mj}+\beta_4 HET_{imj}+\beta_5 PLA_{mj}+\beta_6 MAT_j+\beta_7 TOU+\varepsilon_{imj} \quad (1)$$

Model B

$$P_{imj}=\beta_0+\beta_1 PSY_{imj}+\beta_2 nPER_{imj}+\beta_3 PRI_{mj}+\beta_4 HET_{imj}+b_5 PLA_{mj}+\beta_6 MAT_j+\beta_7 TOU+\varepsilon_{imj} \quad (2)$$

Where P_{imj} is the number of games won by player i during match m in tournament j; PSY_{imj} - psychological variable (1); $pPER_{imj}$ – positive performance variables (5); $nPER_{imj}$ - negative performance variables (5); PRI_{mj} - incentive variable (1); HET_{imj} - heterogeneity variables (3); PLA_{mj}- player variables (4); MAT_j - match variables (2); and TOU- tournament variables (3). Basic descriptive statistics for all of the variables are presented in Appendix C, Table 3.

Dependent Variable ($\boldsymbol{P_{imj}}$)

The metric capturing variation of effort in sports literature varies by sport of course. In team sports and in certain individual sports such as golf, effort is measured by a score relative to the competition or to par in golf (Ehrenberg and Bognano, 1990a, 1990b). Tennis, with its elimination tournament aspect, lends itself more easily to measures to win probability (Easton and Uylangco, 2010; Koning, 2009) if the objective of the study is to identify those aspects of tennis skill which contribute most to winning. Often, if the investigation of strategy in a match of interest, time of match, games played or points played are used as effort measures (Ivankovic, 2007). If one is testing the incentive effects of monetary prizes or match momentum, then games won (Sunde, 2009) or matches won (Wozniak, 2011) are more frequently employed.

We measure the players' effort by the games they won in a particular match. This measure deemed to be a sufficient measure of the effort tennis players exert during a tennis match (Lallemand et al., 2008; Sunde, 2009). We assert that this is especially valid when only the performance of winners is concerned. Specifically, in this case, the variability of the number of games won enables us to make interference not only about the increase or decrease in one's effort, but also to speculate about the quality of the exerted effort, or the efficiency of one's game. To clarify, to win a (best-of-three) tennis match, a player must win the minimum of 12 games. Winning only 12 games indicates an easy win, or a match without substantial resistance from the opponent. Winning more than 12 games indicates that the player has to put more than the required minimum effort to win the match.

Psychological Variable ($\boldsymbol{PSY_{imj}}$)

In press conference interviews, top-twenty players stressed on the importance of being mentally tough during the most important moments during a match.

"… It's purely down on me, what goes on inside my head. No one else can, you know, make that better or change it, you know. You need to do that yourself. Doesn't matter how well you practice. You know, you need to be tough in the matches. I need to get better, you know mentally, because since Australia where I was great in all of the matches, I've been poor." (Murray, 2010a)

"… I was missing a few too many shots, which I wish I hadn't because that could have definitely maybe swung momentum around, given me more confidence to play more sort of forward, more attacking. But missing so many important shots really over and over again obviously took a lot of my confidence away. Then the targets seemed to get smaller and smaller. … " (Federer, 2010d)

"You know, it's hard. Because one or two points decide a match. That's tennis. That's professional tennis. Anybody who plays everybody plays well. It's a matter of the momentum, if you are mentally strong to play the right shot at the right time and to position yourself well. …" (Djokovic, 2010d)

We make inferences about top-ranked payers' level of mental toughness by assessing the psychological demands of a tennis match. To begin with, because we are interested only in the matches where a top-ranked player is a winner, there are three possible scenarios of winning a best-of-three match. That is, (a) winning in two straight sets (WW), (b) winning the match after losing the first set (LWW); and (c) winning the match after losing the second set (WLW). Additionally, a player can win or lose a set by a (a) big margin [B] (i.e., 6-4; 6-3; 6-2; 6-1; 6-0), or (b) small margin [S] (7-5; 7(TB)-6). When we consider all of the possible combinations of the above-mentioned scenarios, we can derive nine distinct scenarios for winning a tennis match. To assess the level of mental toughness that players exhibit in each of these scenarios, we attempted to evaluate the psychological demands of each one of the situations by three criteria. That is, (a) number of sets played; (b) opponent resistance (measured by the number of small-margin sets in a match), and (c) match dynamics. The calculations and elaborate explanation of the derivation process are presented in Appendix D.

In summary, we used the described point system to quantify the three criteria for assessing the degree of mental toughness that tennis players exhibit in matches they win. This enabled us to rank the nine scenarios and develop our theory. In the regression analysis, only the rank order of the nine scenarios was used to create 8 dummy variables. We developed the following theory at the onset of the study:

- One's level of mental toughness is a function of (a) opponent's aversion—accounted for by the number of sets played and the opponent resistance; and (b) the place in a match where a major negative event, or lost set occurs (i.e., 1st set or 2nd set).
- We expect that with the increase in the degree of mental toughness, the effort tennis players put forth will increase too. Additionally, we expect that the degree of mental toughness will increase progressively in the following sequence: WW- WLW – LWW. That is, when one wins a match in two straight sets, he will exhibit the lowest level of mental toughness; and when he wins a match after losing the 1st set, he will exhibit the highest level of mental toughness.
    - Within each of the levels, one's degree of mental toughness will increase progressively from low opponent resistance to high opponent resistance.
- To test this hypothesis, we created eight dummy variables and we used the scenario when one is expected to exhibit the lowest mental toughness (or the instance a player wins in two straight sets by a big margin) as a base. The ranked dummy variables are presented in Table 1.

Table 1: Dummy variables

	Opponent resistance	Match dynamics	Var.
WW	LOW opponent resistance	HOT HAND	BASE
WW	MEDIUM opponent resistance	HOT HAND	PsychD1
WW	HIGH opponent resistance	HOT HAND	PsychD2
WLW	LOW opponent resistance	not HOT HAND, not COLD HAND	PsychD3
WLW	MEDIUM opponent resistance	not HOT HAND, not COLD HAND	PsychD4
WLW	HIGH opponent resistance	not HOT HAND, not COLD HAND	PsychD5
LWW	LOW opponent resistance	not COLD HAND, HOT HAND	PsychD6
LWW	MEDIUM opponent resistance	not COLD HAND, HOT HAND	PsychD7
LWW	HIGH opponent resistance	not COLD HAND, HOT HAND	PsychD8

To reiterate our hypotheses

- Increase in the independent variable, or the level of the player's "mental toughness" will produce increase in the dependent variable (Games Won);
- The magnitude of the increase produced by the each of the dummy variables (depicting different levels of mental toughness) will be as follows:

- PsychD1<PsychD2 (step 1);
- PsychD3<PsychD4<PsychD5 (step 2);
- PsychD6<PsychD7<PsychD8 (step 3);
- PsychD1<PsychD3<PsychD6;
- PsychD4<PsychD7
- PsychD5<PsychD8

In other words, the magnitude of the changes in the dependent variable produced by the dummy variables will have a step-wise progression. Each level within a step will be higher than the corresponding level in the preceding step. However, at the onset of the study, no expectations were set forth for the relation of the last variable of the preceding step and the first variable of the subsequent step. That is,

- PsychD2≤ ≥ PsychD3
- PsychD6≤ ≥ PsychD5

To achieve brevity, the description of the remaining variables is presented in the table below. In addition, we will refer to the studied top-twenty players as "own player".

Table 2: Description of explanatory variables included in the model specifications

Variable	Definition
Positive Performance Variables ($\boldsymbol{pPER_{imj}}$)	
Ace	Number of scored aces during a match
Breakpoints Saved	Number of breakpoints saved during a match
Breakpoint Converted	Number of breakpoints converted during a match
Tiebreak Won in 1st set	Existence of tiebreak won in the 1st set (dummy)
Tiebreak Won in 2nd set	Existence of tiebreak won in 2nd set (dummy)
Negative Performance Variables ($\boldsymbol{nPER_{imj}}$)	
Double Faults	Number of double faults committed during a match
Break points Not Saved	Existence of breakpoints that were not saved (dummy)
Breakpoints Not Converted	Existence of breakpoints that were not converted (dummy)
Tiebreak Lost in 1st set	Existence of tiebreak lost in 1st set (dummy)
Tiebreak Lost in 2nd set	Existence of tiebreak lost in 2nd set (dummy)
Incentive Variable ($\boldsymbol{PRI_{mj}}$)	
Prize Money	$PRI_{mj} = PRIZE_{winning_{current\ round}} - PRIZE_{losing_{current\ round}}$
Heterogeneity Variables ($\boldsymbol{HET_{imj}}$)	
Rank Difference	Own Player Favorite by 1 to 10 ranks (dummy; base) Own Player Favorite by 11 to 50 ranks (dummy 1) Own Player Favorite by 51 to 100 ranks (dummy 2) Own Player Favorite by 101 ranks and more (dummy 3) Own Player Underdog by 1 to 10 ranks (dummy 4) Own Player Underdog by 11 to 50 ranks (dummy 5)
Opponent Current Performance	Percentage of total service points won during a match

Own Player Past Performance	Percentage of total return points won during a match $Past\ Performance_{2009} = \frac{Wins_{hard\ courts}}{Loses_{hard\ courts}}$
	Player Variables ($\boldsymbol{PLA_{mj}}$)
Years Pro	Number of years a player has been a professional player
Height/ Weight Ratio	Measure of player's body composition (cm/ kg)
Hand Compatibility	Playing hand same/ different from opponent's playing hand (dummy)
Country Compatibility	Competing in own, or different country of origin (dummy)
	Match Variables ($\boldsymbol{MAT_j}$)
Round	Finals (dummy; base) Semi-final (dummy 1) Quarter-final (dummy 2) Round 4 (dummy 3) Round 3 (dummy 4) Round 2 (dummy 5) Round 1 (dummy 6)
Average Game Duration	Average Game Duration = $\frac{DURATION_{match}}{GAMES\ PLAYED_{match}}$
	Tournament Variables ($\boldsymbol{TOU}$)
Ladder Structure	7 ladders (dummy, base) 6 ladders (dummy 1) 5 ladders (dummy 2)
Month	January-March (dummy, base) July-September (dummy 1) October-December (dummy 2)
Type	Dummy, indoor=1; outdoor=0

Note: After dividing the year in quarters, we noticed that no hard-court tournaments were held for the period between April and June, thus, we excluded this period.

Results

To study the behavioral responses (i.e., effort put) of top-ranked professional male tennis players to incentives and heterogeneity, we constructed a model depicting various internal and external aspects of one's performance. We created two specifications of the basic model, to single out the effect of positive (Model A) and negative (Model B) events on tennis players' effort in matches they won.

Finally, to control for heterogeneity, we introduced several measures (i.e., rank difference, opponent's current performance, and own player past performance) of ability in the two models, which resulted in four distinct models for this study. Table 3 illustrates the results for all of the models. To follow is a discussion of the results in light of the tournament theory and previous empirical research. Overall, the two main models (Models A and Model B) have an explanatory power of more than 90%. However, it should be noted that the model that counts for negative events occurring during a match has a better explanatory power than the model that counts for positive events occurring during a tennis match. Additionally, the explanatory power of the derivative models (Model A1 and Model B1), or the models that count for the players' heterogeneity in a more complex manner, is higher than the power of the main models (Model A and B). It should be noted though that the magnitude of the change is higher for MA1 (.003) that for MB1 (.001). In light of these results, we can conclude that the determinants of player's effort when winning after being in an advantageous playing situation throughout the match are different from the determinants of player's effort when winning a match from a disadvantageous position.

This conclusion is underlined by the fact that after including variables that count for the player's own ability and the opponent's ability, the change in the explanatory power for the two models is different. That is, when holding everything else the same, difference in players' ability explains more of tennis players' effort when being in advantageous position than when being in disadvantageous position.

Table 3: Regression Results

Variable	Model A	Model A1	Model B	Model B1
CONSTANT	11.602***	12.437***	12.620***	12.945***
Psychological Variables				
PsychD1	1.086***	1.149***	.979***	.987***
PsychD2	2.497***	2.623***	2.165***	2.120***
PsychD3	2.798***	3.009***	2.737***	2.805***
PsychD4	4.971***	5.095***	4.462***	4.491***
PsychD5	6.068***	6.170***	5.661***	5.639***
PsychD6	2.886***	3.016***	2.970***	2.997***
PsychD7	5.163***	5.333***	4.461***	4.499***
PsychD8	6.314***	6.443***	5.110***	5.140***
Performance Variables				
Ace	.028***	.031***		
Breakpoint saved	.002	.002**		
Breakpoint converted	.002	.003		
Double Fault			.001	.002
Breakpoint not saved			-.057	-.050
Breakpoint not converted			-.368	-.352
Tiebreak won 1st set	-.082	-.059		
Tiebreak won 2nd set	-.452***	-.426***		
Tiebreak lost 1st set			1.951***	1.911***
Tiebreak lost 2nd set			1.556***	1.566***
Incentive Variable				
Prize: difference winning and losing current round ($1, 000)	.004***	.004***	.003***	.004***
Heterogeneity Variables				
RD_11-50_HIGHER	.158	.188	.148	.179
RD_51-100_HIGHER	.248	.265*	.125	.162
RD_101+_HIGHER	.257	.293*	.172	.223
RD_1-10_LOWER	.051	.078	.171	.184
RD_11-50_LOWER	.462**	.413*	.317*	.279
OPP_T_SERV_PTS_WON		-.012*		-.002
OPP_T_RET_PTS_WON		-.014*		-.003
OWN_PAST_PERF_2009		-.047***		-.044***
Player Variables				
Years Pro	.006	-.011	.006	-.010
Height/ Weight Ratio	-.315	-.275	-.494**	-.513**
Hand Compatibility	.057	.048	-.022	-.022
Country Compatibility	.021	-.012	.029	-.003
Match Variables				
Round_SF	.169	.193	.255	.189
Round_QF	.402*	.408*	.441**	.469**
Round_R4	.382	.433	.252	.283
Round_R3	.500*	.516*	.537**	.578**
Round_R2	.512*	.501*	.577**	.589***
Round_R1	.564**	.546**	.562**	.577**
Average Game Duration	-.045	.021	-.083	-.055
Tournament Variables				
TournLadder_5	.137	.127	.087	.096
TournLadder_6	.051	.059	-.002	.015
Month_Jul-Sept	.180	.222*	.217**	.256**
Month_Oct-Dec	-.009	.045	.038	.082
Tourn_Outdoor/ Indoor	-.029	-.059	-.031	-.055
Number of Observations	367	367	366	366
R^2	.918	.922	.943	.944
Adj. R^2	.910	.913	.937	.938

Dependent Variable: Games Won

* Significance at p<.10 ; ** Significance at p<.05; *** Significance at p<.01

Psychological Variables

We attempt indirectly to measure tennis players' level of mental toughness and its effect on the effort male professional tennis players put forth in a tennis match, predicting that with increase of the level of mental toughness, the effort would increase in a step-wise manner. The results generally supported our hypotheses. All of the variables have a positive sign and they all are significant at $p<.01$. That is, the more mentally tough a tennis player is, the more effort he puts forth when winning tennis matches. Additionally, the magnitude of the changes in the dependent variable produced by the different levels of mental toughness is also according to our initial expectations. For instance, for Model A

- PsychD1[1.086]<PsychD2[2.497] (step 1, WW);
- PsychD3[2.798]<PsychD4[4.971]<PsychD5[6.098] (step 2, WLW);
- PsychD6[2.886]<PsychD7[5.163]<PsychD8[6.314] (step 3, LWW);
- PsychD1[1.086]<PsychD3[2.798]<PsychD6[2.886];
- PsychD4[4.971]<PsychD7[5.163]
- PsychD5[6.068]<PsychD8[6.314]

It should be noted that the magnitude of the changes produced by the last level of the 1st step is lower than the magnitude of the changes produced by the 1st level of the second step. That is, players' level of mental toughness when winning in three sets by a big margin (esp. winning after losing the second set) is higher than their level of mental toughness when they win a tennis match in two close sets. Additionally, these results indicate that the proposed measure is not a mere reflection of the logic of the game of tennis and indeed gives some insights on the mental aspect of one's game. That is, according to the pure logic of the game of tennis, one might expect that winning a (best-or-three) match in 2 sets will result in winning less games than the games won after winning in 3 sets. However, this is not always the case one can win a match by winning 12, 13, or 14 games in both two and three setters. Additionally, there is no difference in the GW when one loses a set in the beginning of the match (or we have LWW) and when one loses a set in the middle of the match (WLW).

Finally, these results indicate that the level of one's mental toughness is determined by not only the number of sets played and the opponents' resistance throughout the match, but also by the place where a major negative event (i.e., a lost set) occur. As per our expectation, when losing the opening set and winning a match, tennis players exhibit higher levels of mental toughness than when winning the opening set and losing the next set.

For Model B, the regression coefficients of the psychological variables behave in a similar manner as in Model A. That is, they all are positive and significant at $p<.01$. The only difference is that the last level of step 3 (WLW) produces lower increase of the games won (GW) than the last level of step 2 (LWW). When comparing the magnitude of the changes in the dependent variable by the different levels of mental toughness in Models A and B, it was noted that the last levels of step 2 and 3 in Model A indicate larger increase (in comparison with the lowest level of mental toughness) that do their corresponding levels in Model B. Once again, this observation lends support to our previously made inference that determinant of players' effort differ when winning after being in advantageous and disadvantageous position during a match. However, these results should be interpreted with caution, given the fact that, in this study, we consider only winners, winning fewer games, or putting less effort might be an indication of more efficient win. Thus, even after having disadvantage throughout a match, top-ranked players exhibit superiority over their opponents.

Positive Performance Variables

On numerous occasions, tennis players have stressed on the importance of specific point during a match. The following quotes of Robin Soderling depict the importance of reaching a tiebreak in a tennis match as well as the importance of winning certain points to be successful. He stated:

"But, you know, I was pretty sure that my only chance to win the match was to stay calm and hopefully take it to a tiebreak. Then in the tiebreaker everything can happen. … And in the tiebreak like that, there's only one or two points. You know the difference gonna be very small. You know, you have to stay focused and really play well on the important points. Because, you know, there's only going to be one or two points against the serve in every tiebreak." (Soderling, 2010)

To study the effect of positive events occurring in the smaller units of a tennis match (i.e., on point and game level) on tennis players' effort, in Model A we included (a) number of aces scored, (b) percentage of breakpoints saved and converted, and (c) the existence of won tiebreak in the 1st or the 2nd set. At the onset of the study, we predicted that increase in these variables will result in decrease in the dependent variable, or the players will win more efficiently. This hypothesis was supported only by the variables depicting positive events

that occur on a game level (i.e., tiebreak won in the 1st or 2nd set) that determines the outcome of the set. Specifically, winning a tiebreak in the second set results in decrease of the GW by .452 and the difference is statistically significant ($p<0.01$). It should be noted that winning a tiebreak in the opening set results only in reduction of the GW by .082 and the difference is not significant. Thus, it is feasible to infer the observed players were not able to capitalize on the advantage of winning the tiebreak and win more efficiently. The finding that winning a tiebreak in the second set results in reduced effort is somewhat counterintuitive, but it might reflect the fact a player has lost the proceeding and/or won the subsequent sets by a big margin.

Negative Performance Variables

It appears as though at a professional level, oftentimes the difference between winning and losing a match, or playing well and not playing well can be determined by losing a single point in a match. For instance, Andy Roddick stated:

"The difference between playing well and not playing well is, let's say that last game tonight on a deuce point I was able to stick, you know, seven or eight backhands in a row crosscourt to where I felt like he was going to have to play a high-risk shot up the line if he wanted to get out of it. When you're not playing well, you leave one of those short or make an unforced error. I think that point is kind of a microcosm of playing well and not playing well." (Roddick, 2010)

To study the effect of negative events occurring the smaller units of a tennis match (i.e., on point and game level) on tennis players effort, in Model B we included (a) number of double faults committed, (b) the existence of breakpoints that were not saved and not converted, and (c) the existence of lost tiebreak in the 1st or the 2nd set. At the onset of the study, we hypothesized that increase in these variables will result in increase in the dependent variable. Thus, facing setbacks during a match will result in putting more effort. Similar to the positive events in Model A, in Model B only the tiebreak variables met our expectations. Specifically, losing a tiebreak in the first or the second set resulted in wining more games and it is statistically significant at $p<0.01$. The increase of effort after facing a major setback can be an indication of a harder fought (both players) match and it can be attributed to one's ability to mentally overcome adversity.

Incentive Variable

In light of the tournament theory, to study the behavioral responses of professional tennis players to monetary incentives, we used the difference in the prize money between winning and losing a current match as an incentive measure. The results for all of the model specifications confirmed the theory prediction and were in line with previous empirical findings that increase in incentives results in increase in effort.

Heterogeneity Variables

To control for heterogeneity among the opponents we used three measures: (a) rank difference, (b) opponent's current performance (measured by the total service and return points won), and (c) own player's past performance (measured by the win-loss ratio for 2009). According to previous empirical results, the higher the rank difference between the opponents the less effort they will put forth in a tennis match. Our results did not corroborate these findings, rather increase in the rank difference (in both directions) results in increase in effort, or the larger the difference the harder fought the match is. For instance, when own player is an underdog by a big margin (i.e., 11 to 50 ranks; it should be noted that even though in the beginning of the calendar year of 2010, all of the own players were in the top 20, during the year some of the players changed their rankings substantially, which resulted in having a top-20 player as an underdog by a margin of 11to 50 ranks.), he wins .462 (Model A), or .317 (Model B) more games than in the case when he is a favorite by a small margin (i.e., 1 to 10 ranks). Although counterintuitive this finding can be explained with the fact that despite one's lower rank, he over performs than predicted because he was a top-ranked player in the past and he has been provided with sufficient motivation (De Corral and Prieto-Rodriguez, 2010). Additionally, the finding that increase in the rank difference when own player is a favorite results in increased effort as well might be an indication of the increased motivation of the underdogs to succeed against a top-ranked player, or own player's underestimating the opponent. Finally, these results can be explained with the small marginal differences between professional tennis players' skill level, which is captured by the following quote:

"No, I think this just show how the tour is pretty tough, you know, how the players are really strong, and the small difference between all the players. … As you can see now, so many other

players, even if they are 50, 60, me, 20 can beat the top guys and go through. So just show how the tennis right now is so close, and that's it." (Berdych, 2010b)

The results regarding the opponent's current performance are also contrary to our initial expectations. That is, increase in opponent's performance results in decrease in own player's effort (the result is significant only in Model A). Given the fact that we are considering the effort put by the winner of the match, it is feasible to assume that despite the improvement of the opponent's performance, the observed players manage to win their matches efficiently (by putting less effort). In other words, this can be an indication of skill and/ or mental superiority.

Finally, the results regarding the impact of one's achievements on the effort put are in contrast to our initial predictions and previous empirical findings. That is, this variable has negative sign and it is significant at $p<.01$ for both models. To elaborate, having a better win-loss ratio in the past results in decrease in effort , or fewer games won, which can be attributed to pure skill superiority and/ or experienced confidence.

Player Variables

We utilized four variables to count for factors pertinent to player specificity: (a) number of years as a professional, (b) height/ weight ratio, (c) hand compatibility (which counts for differences in playing styles), and (d) country compatibility (which counts for utilizing the advantage of playing in own country of origin). Despite of previous findings that the aforementioned characteristics are factors contributing to success in tennis, in this study none, but height/ weight ratio for Model B only, deemed to be a significant contributor to explaining the effort put by top-ranked tennis players.

The fact that the height/ weight ratio was the only significant variable ($p<0.05$) and only for Models B and B1 deserves further attention. The fact that increase the height/ weight ratio results in decrease in the effort might be an indication that when a player is in disadvantageous playing position during a match, he is able to capitalize on his physical superiority (i.e., in tennis, height is positively linked with serving abilities).

Match Variables

To count for possible effect of the quality of a match and experienced fatigue, we included 6 dummy variables for the played rounds and a measure of the average game duration in the models. To elaborate, we refer to a round a particular match is played as a quality of competition because rounds within a tournament differ in the rank differences between the opponents, in the early rounds top-ranked players are matched with lower-ranked players. Additionally, different rounds differ in terms of incentives as well. That is, in the early rounds the difference between winning and losing a round is substantially smaller that the difference in the incentives in the final rounds. The average game duration did not seem to have a significant effect on the effort put. However, the findings regarding the effect of the round played are contrary to the tournament theory predictions and previous research. That is, in this study, the more distant the round is from the finals the more effort the players put forth. The observed differences for the first three rounds and the quarterfinal are statistically significant for all of the specifications of the base model. A finding deserving attention is the fact that the highest increase in the effort (in comparison with the effort put in the final round) is recorded in the first round of a tournament (for models A and A1) or the second round (for models B and B1). A feasible explanation of this finding might be the fact that, in the first rounds, the opponents have more incentive to play harder against a top-ranked player and/ or the top-ranked players underestimate the opponents and they are forced to play harder to achieve success. This inference is supported by the following quote of Novak Djokovic:

"Well, look, as I said, it's not easy. I mean, everybody expects top seeds to go through the quarters, semis with no problems. But you know it's always difficult to play in the opening rounds against somebody who went through qualifying or been a couple of days more than you here and has nothing to lose. You know, it can happen." (Djokovich, 2010e)

Furthermore, Andy Murray also have stressed on the challenges one faces while going through the first rounds by adding to the discussion the role of mental fatigue as a performance disruption factor. He stated:

"You know, you have to win the first few rounds to do it [winning a tournament], and you have to work hard and fight really hard at the start, you know. You see Novak, you know, had to fight hard yesterday; Roger had to do the same a few days ago. You know, we need to be on our game early in the tournament, and that can be difficult mentally if you have to do it week in, week out." (Murray, 2010b)

Tournament Variables

To control for the quality of a tournament, we introduce 5 dummy variables that depict the effect of (a) the stages the player needs to overcome to reach the final prize, (b) the month a particular tournament is played, and (c) the type of the environment (outdoor or indoor). None of the variables, but one of the month dummy variables has a significant effect in explaining the effort put by top-ranked players. Specifically, it appears that playing in the third trimester of the year results in increase in one's effort (in comparison with the first trimester), which is statistically significant in models B and B1 at $p<.05$, and at $p<.10$ in model A1.

These findings can be partially explained with the fact that tennis players prioritize when preparing and performing in tournaments. Several players have directly or indirectly acknowledged the fact that they selectively put their best effort forth depending on the importance of the tournament they play in. For instance, Novak Djokovic stated that "… these [Grand Slams] are most important tournaments for us, so we try to prioritize them and set up our shape for these events" (Djokovich, 2010f).

Conclusion

The results from the present study revealed that major determinants of the effort male professional tennis players put forth in matches they win are (a) mental toughness, (b) incentives, (c) own skills, (d) positive and negative events occurring in the major units (i.e., game) of a tennis match, and (e) quality of competition. Additionally, models (B and B1) that count for the fact that the player has a disadvantageous playing position during a match have a better explanatory power than models (A and A1) that count for the fact that the player has an advantageous position during a match. This finding suggests that the level and quality of the effort put forth while in different playing circumstances is determined by different factors.

Moreover, the fact that (with everything held the same) negative circumstances explain more of the variance in one's effort might suggest that experiencing temporal success during matches does not fully determine the exerted effort and the subsequent success in tennis. The latter finding can be regarded as a contribution to the literature suggesting that hot hand effect, or momentum might be more of belief than reality in professional sport (Fry and Shukairy, 2012).

To extend this research and gain a better understanding about the effect of positive and negative events in a tennis match, it would be beneficial to study the matches that finish in two and three sets separately. Given the fact that in this study we examined the determinants of effort only in the situations that one achieves success, it would be beneficial to study the determinants of one's effort when he loses a match. Moreover, Weinberg et al (2011) have acknowledged that one can be mentally tough regardless of the outcome of the competition; thus, it would be interesting to see how different levels of mental toughness would influence one's effort when losing a tennis match. Finally, the focus of this research was delimited to top-ranked male players who compete on hard courts in ATP World Tour 250, ATP World Tour 500, and ATP World Tour 1000, it would be beneficial to extend this research beyond these categories.

References

Ariely D, 2009. Large stakes and big mistakes. Review of Economic Studies, 76, 451-469.

Bar-Eli M, Avugos S, Raab M, 2006. Twenty years of "hot hand" research: Review and critique. Psychology of Sport and Exercise, 7, 525-553.

Berdych T, 2010a. Press conference interview transcript. Available at http://www.asapsports.com/show_interview.php?id=62608.

Berdych T, 2010b. Press conference interview transcript. Available at http://www.asapsports.com/show_interview.php?id=62539.

Del Corral J, Prieto-Rodriguez J, 2010. Are differences in ranks good predictors for grand slam tennis matches? International Journal of Forecasting, 26, 551-563.

Djokovich N, 2010a. Press conference interview transcript. Available at http://www.asapsports.com/show_interview.php?id=61686.

Djokovich N, 2010b. Press conference interview transcript. Available at http://www.asapsports.com/show_interview.php?id=65698.

Djokovich N, 2010c. Press conference interview transcript. Available at http://www.asapsports.com/show_interview.php?id=62158.

Djokovich N, 2010d. Press conference interview transcript. Available at http://www.asapsports.com/show_interview.php?id=61629.

Djokovich N, 2010e. Press conference interview transcript. Available at http://www.asapsports.com/show_interview.php?id=61601.

Djokovich N, 2010f. Press conference interview transcript. Available at http://www.asapsports.com/show_interview.php?id=62375.
Dohmen T, 2008. Do professionals choke under pressure?. Journal of Economic Behavior and Organization, 65, 1536-1557.
Easton S, Uylangco K, 2010. Forecasting Outcomes in Tennis Matches Using Within-Match Betting Markets. International Journal of Forecasting, 26.
Ehrenberg R, Bognano, M, 1990a. Do Tournaments have Incentive Effects. Journal of Political Economy,98(6), 1307-1324.
Ehrengerg R, Bognano, M, 1990b. The Incentive Effects of Tournament Revisited: Evidence from the European
PGA Tour. Industrial and Labor Relations Review,43(3), 74S-88S.
Federer R, 2010a. Press conference interview transcript. Available at http://www.asapsports.com/show_interview.php?id=62538.
Federer R, 2010b. Press conference interview transcripts. Available at http://www.asapsports.com/show_interview.php?id=67041.
Federer R, 2010c. Press conference interview transcript. Available at http://www.asapsports.com/show_interview.php?id=62066.
Federer R, 2010d. Press conference interview transcripts. Available at http://www.asapsports.com/show_interview.php?id=67068.
Fry M, Shukairy A, 2012. Searching for momentum in NFL. Journal of Quantitative Analysis in Sports, 8(1).
Gilsdorf K, Sukhatme V, 2008a. Testing Rosen's sequential elimination tournament model. Journal of Sports Economics, 9, 287-303.
Gilsdorf K, Sukhatme V, 2008b. Tournament incentives and match outcomes in women's professional tennis. Applied Economics, 40, 2405-2412.
Harbaugh R, Klumpp T, 2005. Early round upsets and championship blowouts. Economic Inquiry, 43, 316-329.
Jones G, Hanton S, Connaughton D, 2002. What is this thing called mental toughness? An investigation of elite sport performers. Journal of Applied Sport Psychology, 14, 205-218.
Ivankovic M, 2007. The Tournament Model: An Empirical Investigation of the ATP Tour. Journal of Economics and Business, 25(1), 83-111
Lallemand T, Plasman R, Rycx F, 2008. Women and competition in elimination tournaments: Evidence from professional tennis data. Journal of Sports Economics, 9, 3-19.
Livingston J, 2012. The hot hand and the cold hand in professional golf. Journal of Economic Behavior & Organization, 81, 172-184.
Malueg D, Yates A, 2010. Testing contest theory: Evidence from best-of-three tennis matches. Review of Economics and Statistics, 92, 841-864.
McFall T, Knoeber C, Thurman W, 2009. Contests, grand prizes, and the hot hand. Journal of Sport Economics, 10, 236-255.
McHale I, Morton A, 2011. A Bradley-Terry type model for forecasting tennis match results. International Journal of Forecasting, 27, 619-630.
Murray A, 2010a. Press conference interview transcript. Available at http://www.asapsports.com/show_interview.php?id=62479.
Murray A, 2010b. Press conference interview transcript. Available at http://www.asapsports.com/show_interview.php?id=62096.
Roddick A, 2010. Press conference interview transcript. Available at http://www.asapsports.com/show_interview.php?id=62162.
Rosen S, 1986. Prizes and incentives in elimination tournaments. The American Economic Review, 76, 701-715.
Soderling R, 2010. Press conference interview transcript. Available at http://www.asapsports.com/show_interview.php?id=62273.
Sunde U, 2009. Heterogeneity and performance in tournaments: a test for incentive effects using professional tennis data. Applied Economics, 41, 3199-208.
Weinberg R, Butt J, Culp B, 2011. Coaches' views of mental toughness and how it is built. International Journal of Sport and Exercise Psychology, 9(2), 156-172.
Wozniak D, 2011. Gender differences in a market with relative performance feedback: Professional tennis players. Journal of Economic Behavior & Organization, 83(1), 158-171.

Appendix A: Player Characteristics

Name	Nationality	Age	Years Pro	Ranking Jan 4th 2010	Ranking Dec 27th 2010	Earnings 2009	Earnings 2010	W-L 2009	W-L 2010
Roger Federer	SUI	28	12	1	2	$6,761,805	$6,685,303	61-12	65-13
Rafael Nadal	ESP	23	9	2	1	$5,414,603	$8,462,984	66-14	71-10
Novak Djokovic	SRB	22	7	3	3	$4,813,063	$3,743,806	78-19	61-18
Andy Murray	GBR	22	5	4	4	$3,997,231	$3,466,861	66-11	46-18
Juan Martin Del Potro	ARG	22	5	5	258	$4,392,743	$95,273	54-16	3-3
Nikolay Davydenko	RUS	28	11	6	22	$3,636,773	$946,156	57-17	30-19
Andy Roddick	USA	27	10	7	8	$2,157,357	$1,901,336	48-15	48-19
Robin Soderling	SWE	25	9	8	5	$2,114,547	$3,325,501	49-21	57-22
Fernando Verdasco	ESP	26	9	9	9	$1,663,863	$1,668,109	52-25	43-22
Jo-Wilfried Tsonga	FRA	24	6	10	13	$1,388,191	$1,138,021	53-20	31-16
Fernando Gonzalez	CHI	29	11	11	68	$1,289,662	$274,358	39-16	15-9
RadekStepanek	CZE	31	14	12	62	$1,122,113	$337,453	47-21	18-16
Gael Monfils	FRA	23	6	13	12	$1,283,211	$1,261,739	42-19	46-20
Marin Cilic	CRO	21	5	14	14	$1,195,475	$1,130,857	48-21	40-22
Gilles Simon	FRA	25	8	15	41	$1,096,521	$523,792	45-29	23-18
Tommy Robredo	ESP	27	12	16	50	$1,069,870	$498,691	46-25	20-23
David Ferrer	ESP	28	10	17	7	$969,237	$2,291,307	45-23	60-24
Tommy Haas	GER	31	14	18	372	$914,319	$68,499	31-17	3-4
Mikhail Youzhny	RUS	27	11	19	10	$966,630	$1,548,895	42-28	43-19
Tomas Berdych	CZE	24	8	20	6	$732,539	$2,221,660	36-26	45-26

Appendix B: Tournament Specifics

Type	Number of tournaments			Average	
	Indoor	Outdoor	Total	Total prize money	Winner prize money
ATP Tour 250	11	10	21	$615,963.14	$108,605.19
ATP Tour 500	4	4	8	$1,532,288.88	$362,939.75
ATP Tour 1000	1	5	6	$3,085,715.33	$557,611.83

Appendix C: Variable Descriptive Statistics

Type	Variable	Measure	Mean	SD
Dependent Variable				
	Games Won	Numeric	13.75	2.23
Psychological Variables				
	PsychD1	Dummy, 0=NO; 1=YES	.23	.42
	PsychD2	Dummy, 0=NO; 1=YES	.04	.19
	PsychD3	Dummy, 0=NO; 1=YES	.04	.20
	PsychD4	Dummy, 0=NO; 1=YES	.07	.26
	PsychD5	Dummy, 0=NO; 1=YES	.04	.19
	PsychD6	Dummy, 0=NO; 1=YES	.06	.24
	PsychD7	Dummy, 0=NO; 1=YES	.05	.22
	PsychD8	Dummy, 0=NO; 1=YES	.05	.21
Performance Variables				
	Ace	Numeric	7.05	4.74
	Double Fault	Numeric	2.20	2.00
	Breakpoint saved	Numeric (%)	58.97	35.65
	Breakpoint converted	Numeric (%)	48.89	23.04
	Breakpoint not saved	Dummy,0 =some BP saved; 1=no BP saved	.06	.24
	Breakpoint not converted	Dummy, 0=some BP converted; 1= NO	.02	.13
	Tiebreak won 1st set	Dummy, 0=NO; 1=YES	.15	.36
	Tiebreak won 2nd set	Dummy, 0=NO; 1=YES	.12	.33
	Tiebreak lost 1st set	Dummy, 0=NO; 1=YES	.04	.20
	Tiebreak lost 2nd set	Dummy, 0=NO; 1=YES	.04	.20
Incentive Variable				
	Prize: difference winning and losing current round ($1, 000)	Numeric	32.12	46.64
Heterogeneity Variables				
	RD_11-50_HIGHER	Dummy, 0=NO; 1=YES	.43	.50
	RD_51-100_HIGHER	Dummy, 0=NO; 1=YES	.21	.41
	RD_101+_HIGHER	Dummy, 0=NO; 1=YES	.15	.35
	RD_1-10_LOWER	Dummy, 0=NO; 1=YES	.07	.26
	RD_11-50_LOWER	Dummy, 0=NO; 1=YES	.04	.20
	OPP_T_SERV_PTS_WON	Numeric (%)	57.63	7.78
	OPP_T_RET_PTS_WON	Numeric (%)	28.83	6.87
	OWN_PAST_PERF_2009	Numeric	3.21	2.57
Player Variables				
	Years Pro	Numeric	8.88	2.44
	Height/ Weight Ratio	Numeric		
	Hand Compatibility	Dummy, 0=NO; 1=YES	.21	.41
	Country Compatibility	Dummy, 0=NO; 1=YES	.18	.38
Match Variables				
	Round_SF	Dummy, 0=NO; 1=YES	.09	.29
	Round_QF	Dummy, 0=NO; 1=YES	.16	.36
Match Variables (cont.)				
	Round_R4	Dummy, 0=NO; 1=YES	.03	.18
	Round_R3	Dummy, 0=NO; 1=YES	.12	.33
	Round_R2	Dummy, 0=NO; 1=YES	.35	.48
	Round_R1	Dummy, 0=NO; 1=YES	.19	.39
	Average Game Duration	Numeric (min)	4.32	.60
Tournament Variables				
	TournLadder_5	Dummy, 0=NO; 1=YES	.54	.50
	TournLadder_6	Dummy, 0=NO; 1=YES	.29	.45
	Month_Jul-Sept	Dummy, 0=NO; 1=YES	.22	.41
	Month_Oct-Dec	Dummy, 0=NO; 1=YES	.35	.48
	Tourn_Outdoor/ Indoor	Dummy, 0=NO; 1=YES	.37	.49
Number of Observations		369		

Appendix D: Evaluation Psychological Demands of Tennis Match

VARIATIONS		SETS PLAYED		OPPONENT RESISTANCE		MATCH DYNAMICS		TOTAL PTS
		NUMBER	PTS	DEGREE	PTS		PTS	
W	BB	2	1	0	1	WW	1	3
W	BS & SB	2	1	1	2	WW	1	4
	SS	2	1	2	3	WW	1	5
W	BBB	3	2	0	1	W-L & L-W	0+2	5
L	BSB &SBB &BBS	3	2	1	2	W-L & L-W	0+2	6
W	SSB &BSS &SBS &SSS	3	2	2	3	W-L & L-W	0+2	7
W	BBB	3	2	0	1	L-W & W-L	2+1	6
W	BSB &SBB &BBS	3	2	1	2	L-W & W-L	2+1	7
	SSB &BSS &SBS &SSS	3	2	2	3	L-W & W-L	2+1	8

To elaborate,

Sets Played: When a player plays 3 sets, he needs to overcome more psychological adversity than if one wins in 2 sets; thus, to count for this difference in the psychological demands, we assess the three-set matches with 2 points and the two-set matches with 1 point.

Opponent Resistance: When a player wins a set by a small margin (i.e., 7-5, 7-6) means that he had to overcome more adversity than if he had won by a big margin (e.g., 6-0; 6-1). In other words, when a set is close, one experiences more "mini-loses", or losing more games during a match. Thus, we measured the level of adversity by the number of small-margin sets in a match. To quantify the opponent resistance, we set forth the following criteria:

- 0 small-margin set – low opponent resistance; here, even though the player wins by a big margin the opponent still wins some low number of games, or points;
- 1 small-margin set – medium opponent resistance; and
- 2 or 3 small-margin sets – high opponent resistance

Match Dynamics: To evaluate this category we used the following two propositions:

- Success leads to Success – Hot Hand (Momentum)
- Failure leads to Failure – Cold Hand

Because we are interested solely in best-of-three matches, there is no "failure leads to failure" scenario; thus, in this case we observe

- Success leads to success (WW) – "hot hand, or momentum" - for the purpose of this assessment, we will assume that this scenario has a neutral psychological response; that is, a player gains a lead and he maintains it, or he is capitalizing on his previous own success and we gave an assessment value of1to this scenario;
- Success leads to Failure (WL) – "not hot hand", which carries a negative psychological response; that is, a player has a lead and the psychological advantage associated with, but he was not able to maintain it. We gave an assessment value of 0 to this scenario; and
- Failure leads to Success (LW) – "not cold hand", which carries a positive psychological response; that is, despite of one's failure in the first set, he was able to elevate his game in the second. We gave an assessment value of 2 to this scenario.

It should be noted that the aforementioned scenarios are the three scenarios when only two sets are played; however, in best-of-three matches there are instances, where the match is decided in the third set. In the latter case, the psychological response from the first two sets carries over to the third set, or we have

- Success to failure in the first 2 sets (which was said to carry a negative response) leads to success in the 3rd set; thus, the overall assessment of this scenario will be 0+2=2pts;
- Failure to Success in the 1st set leads to Success in the 3rd set, thus, the overall assessment of this scenario will be 2+1=3pts.