Universität St.Gallen

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October 2017 Discussion Paper no. 2017-19

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Publisher: School of Economics and Political Science
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Phone +41 71 224 23 25
Electronic Publication: http://www.seps.unisg.ch

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Abstract

Discouragement effect of the lagging player in multi-stage contests is a well-documented phenomenon. In this study, we utilize data from 2,247 Davis Cup matches in teams' tennis tournaments to test the effect of ahead-behind asymmetry on individuals' performance with and without intermediate prizes. Using several different strategies to disentangle the effect of being ahead in the interim score from the effect of selection, we find that a higher-ranked player has higher probability of winning if his team is leading before the respective match. However, this effect disappears in matches in which a winner receives ranking points. This result is driven by an increased winning probability of the lagging favorite. Our findings suggest that, as predicted by previous theoretical studies, intermediate prizes may mitigate or even terminate the ahead-behind effects that arise in multi-stage contests.

Keywords

Collective decision-making, multi-stage contests, discouragement, tennis

JEL Classification

D70, D00, L00, D20, Z20.

1 Introduction

One of the fundamental relationships in the economic environment in general and in tournament settings in particular is the relationship between incentives and performance. It has been well-documented that higher stakes enhance the performance of higher ability agents (Rosen, 1986; Ehrenberg and Bognanno, 1990; Lazear, 2000; González-Díaz, Gossner and Rogers, 2012; Jetter and Walker, 2015). Another important feature that is frequently found in multi-stage tournaments is the ahead-behind asymmetry, where one contestant has an advantage over the other by having a better previous performance. Such situations may occur in R&D contests (Harris and Vickers, 1987), political campaigns (Klumpp and Polborn, 2006), job promotions (Tsoulouhas, Knoeber and Agrawal, 2007), sports competitions (Malueg and Yates, 2010), etc. This ahead-behind asymmetry creates a discouragement effect, according to which a lagging player has lower incentives to exert costly efforts and therefore loses with higher probability in the following stages.[1] There is also a psychological explanation according to which ahead-behind asymmetry creates an additional psychological pressure on the lagging player, which in turn harms his performance and reduces his probability of winning (Genakos and Pagliero, 2012; Genakos, Pagliero and Garbi, 2015; González-Díaz and Palacios-Huerta, 2016).

The combination between incentives and ahead-behind asymmetry was studied theoretically by Konrad and Kovenock (2009). They showed that intermediate prizes in multi-stage contests may mitigate the discouragement effect on the lagging player. The intuition behind

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[1] For example, Klumpp and Polborn (2006) theoretically showed that in sequential elections between two candidates, the loser of the first district has a lower incentive to exert costly effort in the second district, thereby yielding an increased probability for the winner of the first district to win again. Malueg and Yates (2010) found that the winner of the first set in tennis match between equally skilled players has a higher probability to win in the second set. Finally, Gill and Prowse (2012) found the discouragement effect in experimental sequential tournament, by showing that the second-mover reacted negatively to the effort of the first-mover.

this result is that a lagging player has higher incentives to exert effort in every stage, since the player competes for an additional prize that can be achieved regardless of the interim gap between the players. In a more recent theoretical study, Fu, Lu and Pan (2015) investigated multi-stage contest, where individuals from two teams compete in pairwise battles. In their model, a team that wins in the majority of battles receives a team prize and, additionally, the winner of each pairwise battle receives an individual prize. The authors established the so-called strategic neutrality, according to which the existence of an individual prize eliminates any ahead-behind effect and the probability of winning in every single battle only depends on the players' innate ability and not on the outcome of the past battles.

In general, studying the performance of individuals within a team framework is an important economic task. This is because in most professions, teamwork is the rule rather than the exception. For example, a recent report by the European Foundation for the Improvement of Living and Working Conditions (Eurofound, 2014) holds that, in 31 out of 37 sectors, teamwork prevails in over 50% of activities. However, studying the performance of individuals in real-life contests between teams is not a trivial task. This is because reality rarely creates situations that allow a clear view of the contribution of individuals to a team's output. Therefore, the empirical literature is scarce and mostly based on laboratory experiments.[2] A notable exception is the orange grove field experiment conducted by Erev, Bornstein and Galili (1993), where the authors found that inter-group competition produced a significantly higher output than in the case when subjects were paid according to their individual output or when they received an equal share of the group's total output.

[2] For example, Van Dijk, Sonnemans and Van Winden (2001) showed in experimental settings that piece-rate and team payment schemes yield the same efforts, whereas a tournament scheme leads to a higher effort. In another experimental study, Dohmen and Falk (2011) found that the output in teams' revenue-sharing scheme was higher than in the fixed-payment structure. For additional references on different aspects in teams' contests, see the comprehensive review of Sheremeta (2017).

In this paper, we are motivated by little empirical evidence from real-life tournaments on the performance of individuals within team framework in general and on the interactive role of incentives and ahead-behind asymmetry in particular. Therefore, the aim of this paper is to test empirically using data from real-life contests, the effect of ahead-behind asymmetry on individuals' performance in multi-stage contests between teams with and without intermediate prizes. To that end, we utilized data from tennis matches in Davis Cup tournament, which is the premier international team event in men's tennis. Each tie between two nations consists of five separate pairwise matches and a team that wins three matches wins the tie.[3] Therefore, by construction, before the second and the fourth matches of the tie one of the teams should have more wins than the other. This allows us studying the performance of the lagging/leading players.[4] In addition, what makes this tournament feasible to investigate the effect of intermediate prizes is the change of the rules that occurred in 2009. According to this change, between the years 2009 to 2015, a player that won a single match in the World Group received individual ranking points. In other years and groups, there were no individual prizes for winning a single match.

Applying data from professional sports where contestants have strong incentives to win has several advantages. First, it eliminates any possible scepticism about applying behavioral insights obtained in a laboratory to real-life situations (Hart, 2005). Second, sports contests involve high-stake decisions that are familiar to agents. Third, it provides a unique opportunity to observe and measure performance as a function of variables such as heterogeneity in abilities and

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[3] Obviously, in our analysis we only use matches of undecided ties in which no team has won three single matches. See more details in Section 2.

[4] It is worth mentioning the paper of Berger and Pope (2011) who showed that basketball teams have a higher probability of winning if they are lagging by a very small margin at half-time.

prizes. Fourth, at each point of time, the contestants have full information on the interim score and the status of the tournament. Indeed, as Kahn (2000) argues, sports data are very unique in that they embody a large amount of detailed information that can be used for research purposes.[5]

Since being ahead or behind in the interim score is not determined randomly (for example, home teams or stronger tennis nations have a higher probability to be ahead in the interim score), we use several different strategies to disentangle the effect of leading/lagging from the effect of selection. First, we estimate the average treatment effect of leading/lagging by using the distance-weighted radius matching approach with bias adjustments suggested by Lechner, Miquel and Wunsch (2011). This approach has been shown to have superior finite sample properties relative to a broad range of propensity score-based estimators (Huber, Lechner and Wunsch, 2013). Furthermore, it is particularly robust when the propensity score is functionally misspecified.[6] The second strategy is based on a recent study by Oster (2016) which assesses the size of the selection bias and the bias-adjusted treatment effect under the assumption that the relationship between the treatment and the unobservables can be recovered from the relationship between the treatment and the observables. These assessments are done by explicitly linking the size of the bias to the coefficient and the R-squared stability.

Based on the analysis of 2,447 matches from 999 international ties, we find a significant ahead-behind influence on players' performance. More specifically, we find that the higher-ranked player has about 4%-points higher probability of winning a match if his team is leading.

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5 Numerous studies have used sports data to explain economic behaviour. For instance, Walker and Wooders (2001) used tennis matches to test the theory of mixed strategy equilibrium empirically. Palacios-Huerta (2003) tested the Minimax theorem using penalty kicks in professional soccer. Finally, Pope and Schweitzer (2010) provided evidence for loss aversion in professional golf.

6 See also Huber, Lechner and Steinmayr (2015) who describe in detail this approach and its implementation in different software packages such as Gauss, Stata and R.

When studying the effect within matches 2 and 4, we find that the effect in match 2 is not significant. However, the effect of being ahead in match 4 is approximately 10%-points, which is relatively large.

This result may have several explanations. First, a lagging player has much more to lose in terms of a team prize. This is because if a lagging player loses in match 4 then his team loses the entire tie. Therefore, such situation may provoke choking under pressure of the lagging player and, as a result, harm his performance and reduce his winning probability.[7] However, our findings may be explained by the choice of effort rather than by (or together with) psychological pressure. This is because in the absence of intermediate prize, namely a prize for winning a single match, the lagging player has less incentive to exert a costly effort and therefore will lose with higher probability (Konrad and Kovenock, 2009; Malueg and Yates, 2010).[8]

While it is not possible to disentangle psychological and strategic explanations in such multi-stage settings, we have a unique opportunity to study the performance of players in tournaments with and without intermediate prizes. As already mentioned, in 2009, the Association of Tennis Professionals (ATP) decided to assign the winners of a single match in Davis Cup with ranking points. These points are taken into account in determining the World Ranking list. Based on this list, players enter the most prestigious tournaments with possibility of earning large monetary prizes. To emphasise the importance of ranking points, many players decided not to participate in the Rio 2016 Olympic tennis tournament in part because of the

[7] See Ariely et al. (2009) who showed that large stakes may decrease performance. Additionally, Paserman (2010) found that the performance of tennis players deteriorates on more important points. Similarly, Cohen-Zada et al. (2017) found that male professional tennis players lose more serves when the pressure is higher.

[8] See Cohen-Zada, Krumer and Shtudiner (2017) on discussion about coexistence of psychological and strategic motives in multi-stage contests.

absence of ranking points in this tournament, which obviously reduced the incentives for participation.[9]

By studying matches in the World Group, with and without intermediate prizes (ranking points in our case), we find evidence of strategic neutrality presented by Fu, Lu and Pan (2015). More specifically, before the decision to assign ranking points for winning a single match, namely in the years from 2003 to 2008, a favorite from the leading team had a higher probability to win in match 4 compared to the favorite from the lagging team. However, in the years from 2009 to 2015, the effect of leading is much closer to zero and highly insignificant. In other words, as predicted by strategic neutrality, the interim score of the tie does not affect a higher-ranked player's winning probability. This result is driven by the increased winning probability of the lagging favorite. More specifically, we find that starting from 2009, the winning probability of a favorite from the lagging team was 20%-points higher than before 2009. Although we cannot rule out the possibility of some other psychological effects, our findings suggest that introduction of intermediate prizes mitigate and may even eliminate the ahead-behind effects that arise in multi-stage contests.

The remainder of the paper is organized as follows: Section 2 describes the Davis Cup setting. The data and descriptive results are presented in Section 3. Section 4 presents the estimation strategy. In Section 5 we present the empirical evidence. Finally, in Section 6 we offer concluding remarks.

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[9] See https://www.nytimes.com/2016/05/30/sports/tennis/points-and-prize-money-mean-more-to-olympic-tennis-holdouts.html for more information on the absence of ranking points in the Rio 2016 Olympic Games (last accessed on 12/07/2017). For additional details on the importance of ranking points see Jetter and Walker (2017).

2 Description of Davis Cup

Davis Cup is an international men's tennis team competition played annually between teams from participating countries. The tournament is structured into five hierarchical levels: World Group, Group 1, Group 2, Group 3, and Group 4. The World Group is the top competition level, comprised of 16 participating nations. Nations that are not part of the World Group compete in one of the lower four groups. Teams in World Group, Group 1 and Group 2 compete in an elimination tournament according to which a winning team is advanced for the next round and the losing team is eliminated. Groups 3 and 4 use a round-robin structure according to which teams play against each other in pairwise ties.[10]

A tie signifies a competition round between two competing countries. In the World Group, for example, the 16 nations play eight pairwise ties of the first round (round of Last 16). The eight winners of this round compete in four Quarterfinal ties. The four winners play two Semifinal ties. Finally, the two winners play the Final tie.

Teams that lose in the first round in groups from World Group to Group 2 face the possibility of being relegated to a lower group for next year's tournament. Promotion or relegation in the World Group is decided in Play-off rounds played between losers of the first round in the World Group and winners of Group 1. To be promoted from Group 2 to Group 1, a team needs to win in three different rounds. A team that loses in three different rounds in Groups 1 and 2 is relegated to the lower Group.

[10] It has been shown theoretically (Krumer, Megidish and Sela, 2017) and confirmed empirically (Krumer and Lechner, 2017) that the probability of winning depends on the schedule of the round-robin tournament. In addition, Krumer, Megidish and Sela (2016) showed that winning probabilities of favourites differ between round-robin and elimination tournaments. Therefore, we concentrate only on the elimination structure used in the World Group, Group 1 and Group 2.

Each tie in the World Group, Group 1 and Group 2 consists of five rubbers (matches), namely four singles matches and one doubles match. Each team consists of several players that are seeded according to their individual World Rankings. On the first day of each tie, two matches are played between the first seeded player of one team and the second seeded of another team. The schedule of the first day is determined randomly. The doubles match is always scheduled as match number 3 that takes place on the second day of the tie. On the third day, the two top seeded players from each team always compete against each other in match 4 and two second seeded players from each team always compete in match 5.

The first team that wins three rubbers wins the tie and progresses to the next round to play a tie against another team. If the tie has not already been decided in favour of one team (no team won three rubbers), then the remaining rubbers are termed as live rubbers, which are played in the form of best-of-five sets. Additionally, all dead rubbers are played in the form of best-of-three sets.[11]

Finally, between the years 2009 to 2015, a player that won a single rubber in the World Group only received ranking points as long as the rubber was defined as a live rubber. In other years and groups there were no individual prizes for winning a single rubber.

3 Data and variables

3.1 Data

As already stated, since there is a difference between round-robin and elimination formats, our dataset consists of Davis Cup matches in the World Group, Group 1 and Group 2 that use the

[11] For additional details see https://www.daviscup.com/en/organisation/rules-regulations.aspx . Last accessed on 10/07/2017.

latter format. In addition, we only consider matches between individuals and do not use matches between doubles because, in most cases, players do not specialise in doubles and play this type of matches only occasionally.

The data were collected from several websites (see Appendix A for a list of all sources). All Davis Cup matches played in the period between the years 2003 and 2015 are present in the datasets. For every match, information is available regarding the names of the players, their previous head to head victories and losses against the opponent, and each player's 52-week ranking prior to the beginning of each match. The ranking is used as a measure of the players' abilities and is calculated and updated weekly by taking into account all the player's results in professional tournaments over the previous 52 weeks. Apart from individual level data, information on the location, group type, year, and tournament round for each tie is also available.

In all, the dataset consists of 4,206 Davis Cup matches. However, we consider only live rubbers (i.e. matches that are still crucial in deciding which team wins the tie). This is because dead rubbers are in the form of best-of-three sets and usually substitute players play in these matches. Therefore, 1,198 dead rubber matches were eliminated. In addition, other 561 matches lacked information regarding current ranking of one of the players, or were not played to completion, and therefore were eliminated as well.[12] Dropping all of these matches leaves 999 Davis Cup ties, consisting of 2,447 matches.

[12] Out of 561 eliminated matches due to missing information or matches that were not completed, 19 matches were from the World Group, 88 matches were from Group 1 and 454 matches were from Group 2. In 7 matches from the World Group, one of the players did not have World Ranking. The corresponding numbers for Group 1 and Group 2 are 69 and 427 respectively.

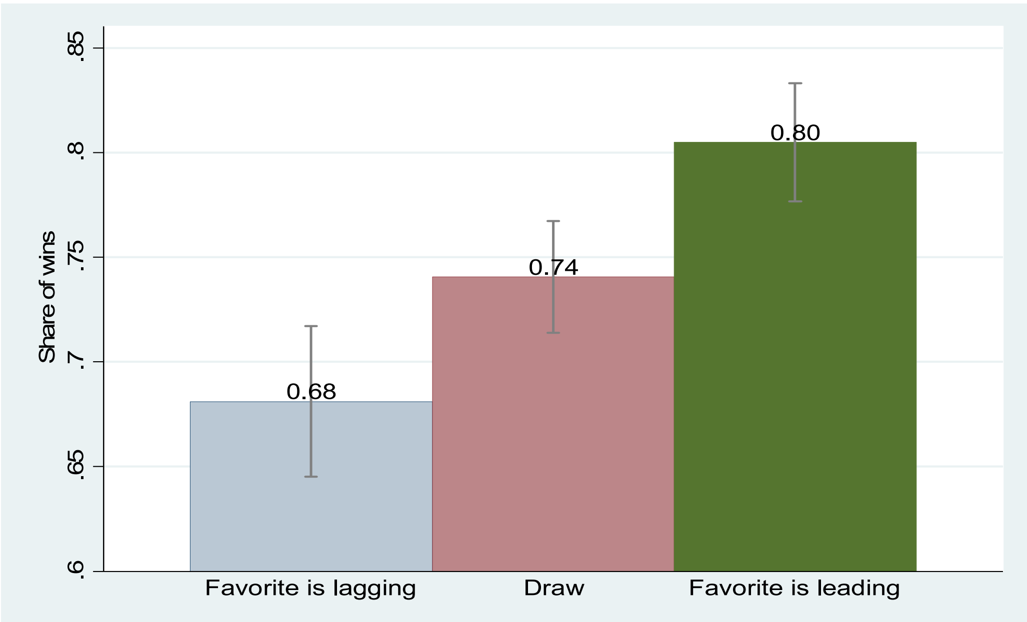
3.2 Variables

For each match, we first define the higher-ranked player as the favorite and the lower-ranked one as the underdog. Then, we estimate the probability that the favorite will win the match. Accordingly, we assign the dependent variable a value of one if the favorite player won and zero otherwise.

It is important to note that a favorite is lagging if the interim score of the tie before the respective match is 0:1 or 1:2 in favour of the opponent's team. A favorite is leading if the interim score of the tie before the respective match is 1:0 or 2:1 in favour of his team. Therefore, to estimate the effect of being ahead/behind in the score, we coded a dummy variable that equals one if *favorite is lagging* before the respective match and zero otherwise. Similarly, we coded a dummy variable that equals one if *favorite is leading* before the respective match and zero otherwise.

The probability of the favorite to win against the underdog is obviously a function of their relative strength. We use two different measures in order to control for the relative strength of the two players. The first one, *DiffRank*, is defined as $\log_2(FavoriteRank) - \log_2(UnderdogRank)$, where $FavoriteRank$ and $UnderdogRank$ are the most current World Rankings of the favorite and the underdog, respectively. The main advantage of this measure is that the differences in players' quality are not linear but rather grow at an increasing rate as we move up the ranking. This implies that a difference of one position in the ranking list corresponds to a smaller difference in quality if the players are at the bottom of the list, but to a more substantial difference when we compare the top contestants (see also Klaassen and Magnus, 2001). Table 1 shows that the mean value of this measure is negative owing to the fact that the favorite is associated with a lower ranking number. The second measure that may provide information about the differences in the abilities of the two players is the difference in head-to-head victories prior to the respective match. Thus, for each match we calculate the number of head-to-head victories in favor of the favorite. This variable, *DiffH2H,* is measured as the difference between the numbers of matches that the favorite and the underdog won in previous head-to-head matches against each other.

Figure 1: Share of wins as function of the status of the match



Notes: This figure presents the means of the share of wins of a favorite at different statuses based on all data. 95% confidence interval is presented.

We also control for the home advantage, which was found to play a significant role in professional tennis (Koning, 2011). Thus, the variable that indicates that the favorite has a home advantage gets the value of one if the favorite competes at home and zero otherwise. In addition, we include dummies for each round and type of group categories. Finally, since starting from 2009 a single win in a live rubber of the World Group guaranteed ranking points, we coded a dummy variable that equals one if the match was in the World Group after 2009 and zero otherwise. The descriptive statistics of our dataset are presented in Table 1. It shows that, on average, the favorite wins in 68.1% of cases if his team is lagging. It also shows that if the favorite's team is leading then his probability of winning is 80.4%. Using 95% confidence interval, Figure 1 shows that the favorite's share of wins in case of leading (1:0 or 2:1) is significantly higher than when the interim score is draw (0:0 or 2:2) or when the favorite's team is lagging (0:1 or 1:2). However, we can also see in Table 1 that if the favorite is leading, he also has a higher measure of home advantage, a better head-to head performance, and a lower ranking index, which is associated with a higher ability. Thus, in order to obtain the causal effect of being ahead/behind, we will use several estimation strategies that control for selection into treatment (leading/lagging). We discuss these strategies in the following section.

4 Estimation strategy

Studying whether being ahead or behind before a Davis Cup match gives an advantage to the favorite is a challenging task. A naïve approach of correlating a dummy variable for leading/lagging with the probability to win a match will yield biased and inconsistent estimates because the status of being ahead or behind is not determined at random. Rather, as mentioned earlier, being ahead is a function of tennis specific features such as home advantage, previous head-to-head meetings, difference in abilities between the other members of teams etc. Furthermore, isolating an exogenous source of being ahead/behind in the score by using an instrumental variable approach seems unfeasible because any factor that might be associated with being ahead/behind is also likely to affect the probability to win the match. In the absence of a valid instrument, we will use several alternative strategies to control for the endogeneity of leading or lagging in Davis Cup matches.

4.1 Radius matching analysis

As a first step, we derive the radius-matching-on-the-propensity-score estimator with bias adjustment (Lechner, Miquel and Wunsch, 2011). Not only was it found to be very competitive among a range of propensity score related estimators, but a later paper Huber, Lechner and Wunsch (2013) actually showed its superior finite sample and robustness properties in a large scale empirical Monte Carlo study. The main idea of this estimator is to compare treated and non-treated observations within a specific radius. The first step consists of distance-weighted radius matching on the propensity score. In contrast to standard matching algorithms where controls within the radius obtain the same weight independent of their location, in the radius matching approach, controls within the radius are weighted proportionally to the inverse of their distance to the respective treated observations they are matched to. The second step uses the weights obtained from this matching process in a weighted linear or non-linear regression in order to remove biases due to mismatches. Because this approach uses all comparison observations within a predefined distance around the propensity score, it allows for higher precision than fixed nearest neighbour matching in regions in which many similar comparison observations are available.

4.2 Oster's bias-adjusted treatment effect

Next, in order to isolate the selection bias and obtain the bias-adjusted treatment effect of leading/lagging, we use a formula suggested by Oster (2016), which calculates the bias-adjusted treatment effect, β^*, as follows:

$$\beta^* = \tilde{\beta} - \delta[\beta^0 - \tilde{\beta}] \cdot \left(R_{\max} - \tilde{R}\right) / \left(\tilde{R} - R^0\right)$$

where $\tilde{\beta}$ and β^0 are the coefficients of the key variable in regressions with and without observed controls, respectively. $\tilde{R}$ and R^0 are the R-squared values of these regressions, respectively. The bias-adjusted treatment effect calculated above is conditional on the size of two parameters: 1) the relative degree of selection on observed and unobserved variables (δ) and (2) the R-squared from a hypothetical regression of the outcome on treatment and both observed and unobserved controls, $R_{\max}$. Like Altonji, Elder and Taber (2005), Oster (2016) suggests that $\delta = 1$ may be an appropriate upper bound on δ. In addition, based on a sample of randomized papers from top journals, Oster determines that $R_{\max} = 1.3\tilde{R}$ may be a sufficient upper bound on $R_{\max}$. This criterion would allow at least 90% of randomized results from the above-mentioned papers to survive. Therefore, we follow the bounds on δ and $R_{\max}$ that Oster suggests and use them in our estimations.

5 Results

5.1 Basic results

We conducted the analysis for the full dataset. As already discussed, there is a selection into being ahead/behind. Although the purpose of the propensity score estimation is only a technical one, namely to allow the easy purging of the results from selection effects, it is nevertheless interesting to see which variables drive selection. In Table 2 we report the results for the propensity score estimation. We use two different specifications. In the first we control for difference in rankings, previous head-to-head results and home advantage. In the second specification, we also control for tie specific features, such as the round of the tournament, the group, year and whether the match is a World Group match before or after 2009. We can see that many variables are associated with being ahead/behind. It is not surprising, since it is expected that home players have a higher probability to win and that players from stronger countries have on average better teammates.

In columns 1 and 2 of Table 3 we present the results for the radius matching estimator where Panel A and Panel B report the average effects for lagging and leading, respectively. The standard errors obtained from the bootstrap are presented in parentheses. The results show that the effect of lagging is negative and significant. It reduces favorite's probability of winning by about 5%-points. The effect of being ahead on the favorite's probability of winning is between 3.7%-5.4%-points and also significant. This finding is in line with ahead-behind asymmetry that has been found in soccer (Apesteguia and Palacios- Huerta, 2010; Palacios-Huerta, 2014) and chess (González-Díaz and Palacios-Huerta, 2016).

Next, in order to conduct the Oster's bias-adjusted treatment effect of leading/lagging, in columns 3 and 4 we present the results of the Linear Probability Model (LPM) with and without the full set of controls respectively where standard errors clustered at the tie level appear in parentheses. Not surprisingly we can see that the size of the coefficients of *Favorite is lagging* and *Favorite is leading* are much higher in an uncontrolled specification presented in Column 3 than in specification with the full set of controls as presented in Column 4.

In Column 5 we present the bias-adjusted treatment effect of lagging/leading. The standard errors obtained from the bootstrap are presented in parentheses. The results show that estimated causal effect is closer to zero, but still significant. When a favorite is lagging, he has 3.7%-points lower probability of winning. The positive effect of being ahead on favorite's probability of winning is 3.6%-points.[13]

[13] Note that in case of lagging our treatment is being behind compared to being ahead or even. Similarly, in case of leading, our treatment is being ahead compared to being behind or even.

It is important to note that our results do not contradict the results of Berger and Pope (2011) who found that being slightly behind (one point) at half-time has a positive effect on winning probabilities in basketball. However, being far behind was less likely to have a positive effect. Since in Davis Cup there are only five matches, then being one match behind is a much more significant lagging than being one point behind in basketball, where teams score about one-hundred points per match. Therefore, we interpret lagging by one match in Davis Cup is further than being slightly behind.

5.2 Ahead-behind asymmetry in matches 2 and 4

In this subsection our aim is to investigate only matches where the score is asymmetric, namely matches 2 and 4, where by construction, one team is leading and the other is lagging before the beginning of the match. Figures 2a and 2b show that on average there is a much higher gap between the share of wins if a favorite is leading in match 4 compared to match 2.

Our empirical analysis presented in Table 4 shows that being ahead has a significant and positive effect on probability of winning in match 4. We find no significant effect of being ahead in match 2.[14] This result is in line with several explanations. First, there may be some psychological effect on the lagging player, such as choking, since the lagging player has much more to lose in match 4 compared to match 2 in terms of a team prize. This is because if a lagging player loses in match 4 then his team loses the entire tie, which is not the case if he loses in match 2, since by definition none of the teams can have three single wins after the second match. If, however, a player whose team is leading loses in match 4, then there is still a chance that his team can win the tie if his teammate wins in match 5. This difference in states that the

[14] In Appendix C we show that the effect of leading in match 4 is significantly higher than in match 2.

two players face in match 4 may have an additional psychological burden on the player from the lagging team.

Figure 2a: Share of wins in match 2

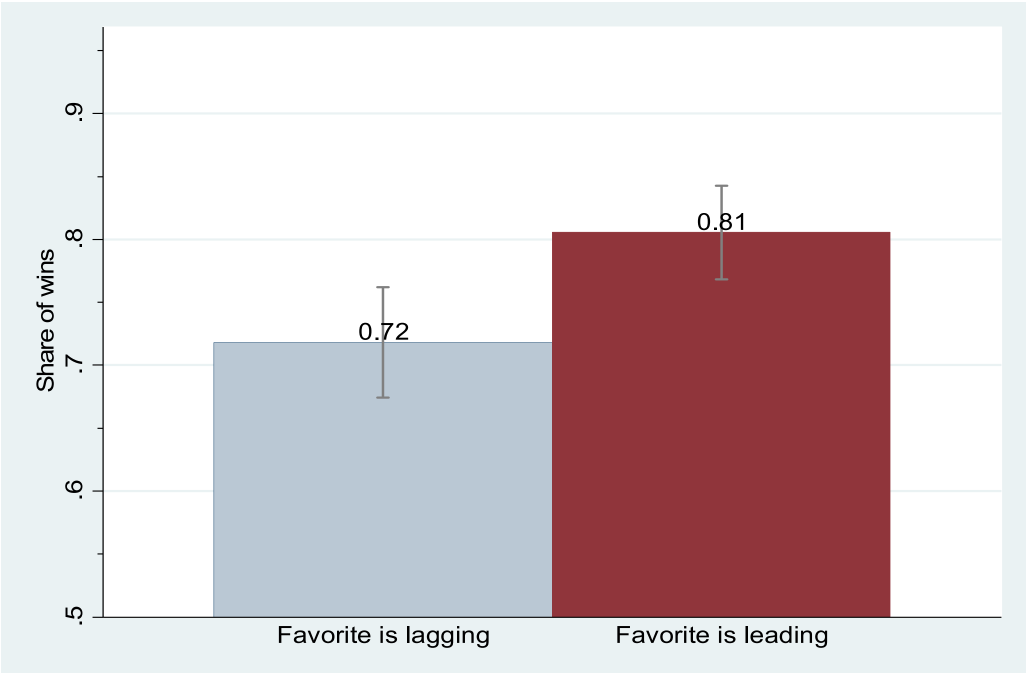
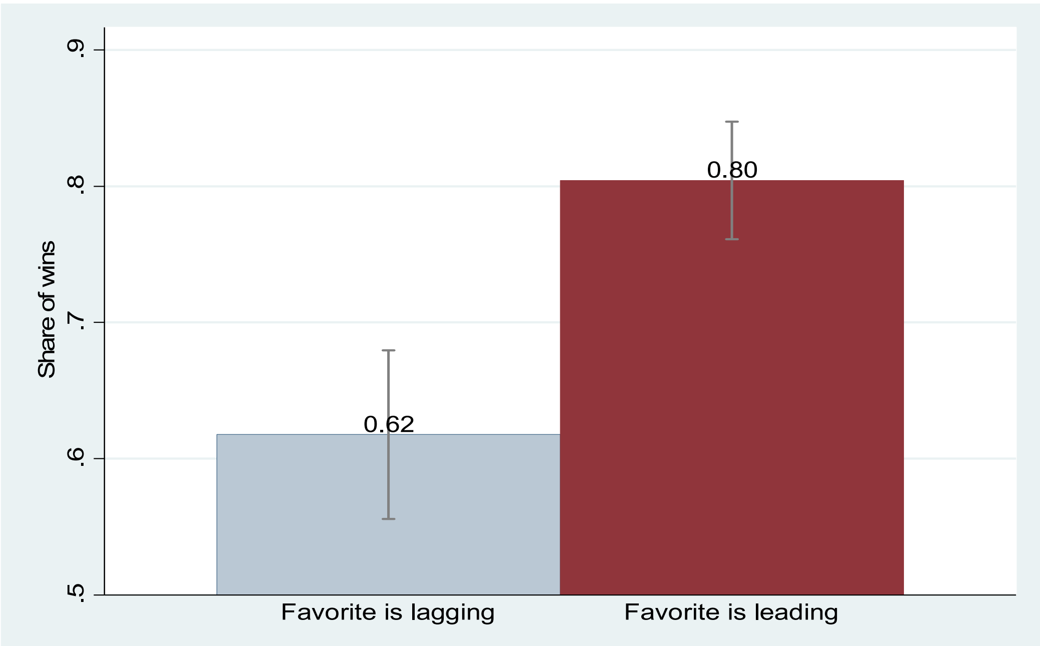


Figure 2b: Share of wins in match 4



Notes: This figure presents the means of the share of wins of a favorite in match 2 (Figure 2a) and match 4 (Figure 2b) based on all the tournaments. 95% confidence interval is presented.

However, there is also an alternative explanation, which may coexist with the previous one. Our findings may be explained by the choice of effort rather than by (or together with) psychological pressure. This is because in the absence of intermediate prize, namely a prize for winning a single match, the lagging player has less incentive to exert a costly effort and therefore will lose with higher probability (Klumpp and Polborn, 2006; Konrad and Kovenock, 2009; Malueg and Yates, 2010). It is also possible that the leading player values his win, more than the lagging player, in match 4 compared to match 2, which may also yield difference in winning probabilities. This difference in valuations between the matches may be driven by simple egocentric motives. For example, the winner of the match that determines the tie gets more glory. This explanation was put forward when, the Portuguese soccer super star, Christiano Ronaldo, decided to take the last penalty kick in the semifinal match of the UEFA European Championships in 2012 in the anticipation that it would be the one to finish off Spain and send Portugal through to the Euro 2012 final.[15]

Although we cannot observe all the possible prizes the players get from winning a single match, in the next subsection we use a unique opportunity to study the effect of the ahead-behind asymmetry in settings with and without intermediate prizes.

5.3 The effect of ranking points introduced in the World Group in 2009

In this subsection, we take an advantage of the change in the rules introduced by the Association of Tennis Professionals (ATP). Up to 2009, players did not receive any ranking points for a single win. However, starting from 2009 and up to 2015, a winner of a live rubber of the World Group received ranking points. These points are taken into account in determining the

[15] From http://www.telegraph.co.uk/sport/football/teams/portugal/9360794/Euro-2012-It-will-haunt-Portugal-talisman-Cristiano-Ronaldo-why-didnt-he-take-the-first-penalty.html . Last accessed on 07/07/2017.

World Ranking list. This list is very important because it determines the entries to the most important tournaments with the highest monetary rewards. It also determines the identity of seeded players in other tournaments. These seeded players benefit from a better draw, since in the first rounds they play against non-seeded players who are on average weaker than the seeded ones. To put this decision into perspective, a win in Davis Cup main tournament was worth 40 - 75 ranking points, depending on the round. This means that two wins in Davis Cup matches was worth more than two wins in the first two rounds of Grand Slams tournaments (55 points), which are the most prestigious tennis tournaments.[16]

As discussed, the intermediate prizes (ranking points) theoretically play a very important role in multi-stage contests. According to Konrad and Kovenock (2009), an introduction of positive intermediate prizes may increase the lagging player's probability of winning. Moreover, according to Fu, Lu and Pan (2015), if there is an intermediate prize, which is common to both players, then the interim score of a tie has no effect on players' probability of winning in a single rubber. This probability only depends on the players' innate abilities. Therefore, we would expect that starting from 2009 the probability of winning would not be affected by the state of the contest (whether a player is leading or lagging).

Indeed, based on the World Group ties, Figure 3a shows that the gap between winning probabilities in case of leading in match 4 compared to being behind was on average 28%-points before the change of the rules in 2009.[17] This gap however, was dramatically reduced to only

[16] Two wins in the playoff of Davis Cup worth 15 points. For additional information see: https://en.wikipedia.org/wiki/Davis_Cup and https://en.wikipedia.org/wiki/ATP_Rankings#Points_distribution_.282009_.E2.80.93_present.29. Last accessed on 07/07/2017.

[17] As previously, no significant differences between winning probabilities were observed in match 2. The results are available upon request.

8%-points after 2009, as shown in Figure 3b. In addition, it is important to note that based on estimations presented in Appendix D, none of the observable characteristics significantly differ between the periods.

Figure 3a: Share of wins in match 4 in the World Group before 2009

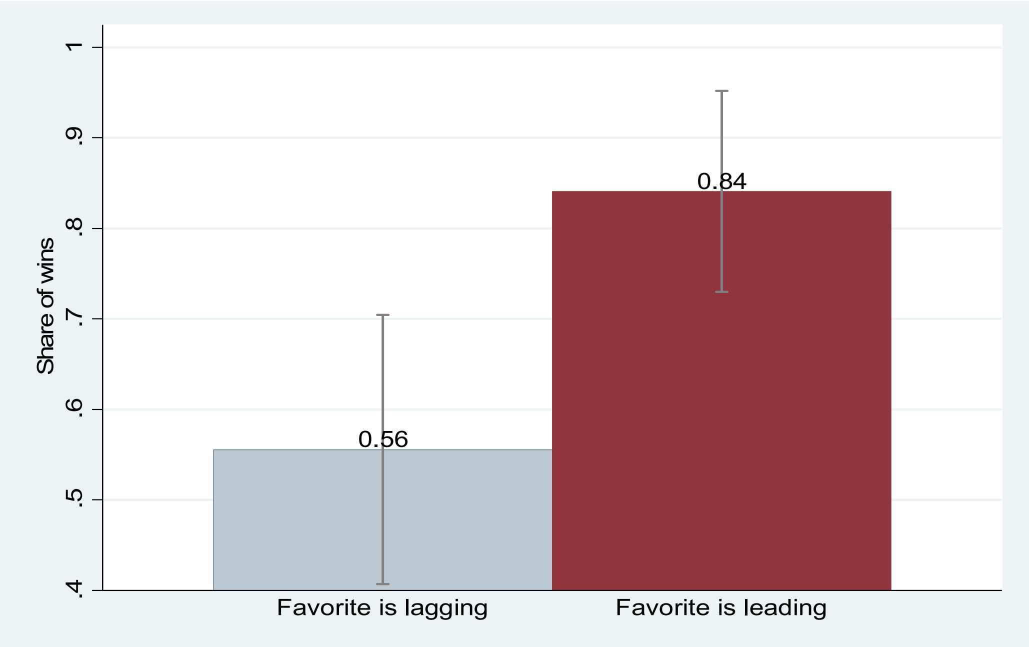
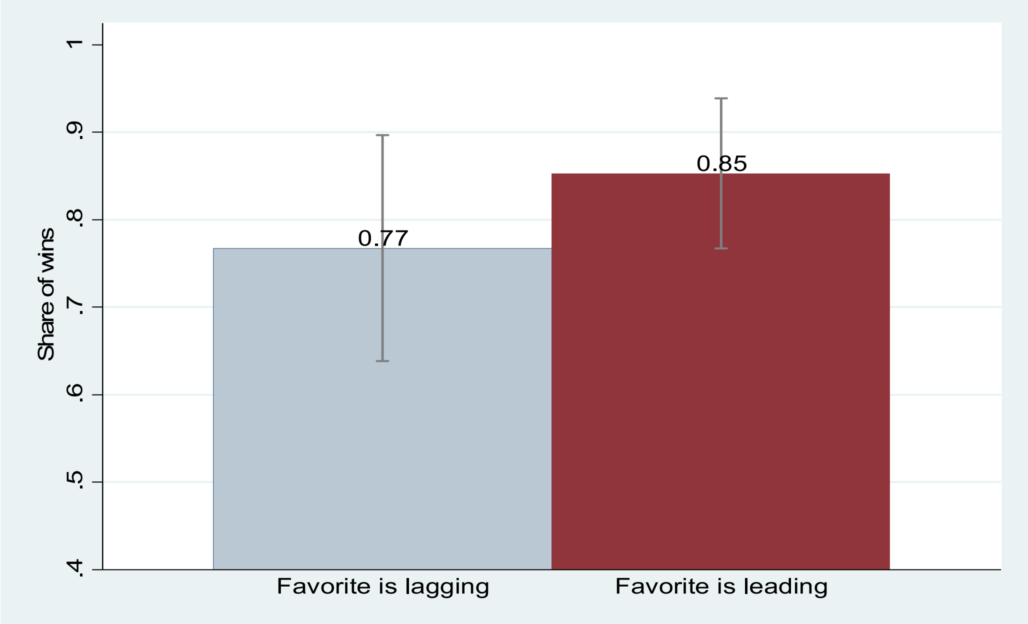


Figure 3b: Share of wins in match 4 in the World Group after 2009



Notes: This figure presents the means of the share of wins of a favorite in match 4 in the World Group before 2009 (Figure 3a) and after 2009 (Figure 3b). 95% confidence interval is presented.

In Table 5, we present the effects of leading in match 4 on the winning probability of a favorite player before and after 2009. The radius matching estimator presented in columns 1 and 2 implies that there is a significant and positive effect of being ahead before 2009, which is much smaller and not significant after 2009.

In columns 3 and 4 we report Oster's bias-adjusted treatment effect. Since there is a very low number of observations, the R-squared is very sensitive to inclusion of any additional variable. Therefore, we follow Oster (2016) who also offers an adjusted procedure for evaluating the bias-adjusted treatment effect when some variables are considered as part of the identification strategy and thus appear both in the controlled and uncontrolled regressions. The idea is to assess the amount of selection on the observables conditional on including these variables in the estimation. Because some of the variables were found to be significant in the propensity score estimation presented in Appendix D it is worthwhile to assess the amount of selection conditional on these variables being included in the estimation as part of our identification strategy. Therefore, in Column 3 of Table 5, the *DiffRank* and *Year2008* are included both in the controlled and uncontrolled regressions. Similarly, since *DiffRank* was found to be significant in the propensity score estimation (column 2 in Appendix D), in Column 4 of Table 5, this variable is included both in the controlled and uncontrolled regressions. The results of these regressions are presented in Appendix E, where we can see that the effects are significant before 2009 and almost unchanged to inclusion of controls (columns 1 and 2 of Panel A in Appendix E). The Oster’s bias-adjusted coefficient is almost the same as in the LPM. However, the bootstrapped standard errors are slightly higher, reducing the significance level to 11.2%. When testing the effect of leading after 2009 we can see that according to all the estimators (in Table 5 and Appendix E) the effect of leading in match 4 is much closer to zero and highly insignificant.

Finally, we test whether the intermediate prizes increase the winning probability of the lagging player as indicated in Figures 3a and 3b. In Table 6, we compare the winning probabilities of the lagging favorites in match 4 before and after 2009. In total, we have 46 such cases before 2009 and 43 after. The radius matching estimator presented in Column 1 implies that the effect of the intermediate prizes on the winning probability of the lagging favorite is 17.6% with significance level of 10.8%. In this case, none of the controls significantly differs between the two periods. In fact, as shown in Appendix F, none of the variables has a p-value lower than 0.27. Therefore, in order to conduct the Oster's bias-adjusted treatment effect, we use the results of the LPM with and without the full set of controls as presented in columns 2 and 3, respectively. We can see that the effect of the post-2009 period is not sensitive to inclusion of the controls. Its size is about 20%-points with significance level of 4.3% and 5.4% in columns 2 and 3, respectively. Not surprisingly, Oster's bias-adjusted coefficient, presented in Column 4 is almost the same as in the LPM, with a significance level of 7.1%.

These results suggest that the introduction of incentives for winning a single match is likely to affect the performance of players. The finding that the probability of winning is not affected by the state of the contest when the intermediate prize is introduced is in line with a theoretical prediction of strategic neutrality presented in Fu, Lu and Pan (2015). Additionally, according to Malueg and Yates (2010), Konrad and Kovenock (2009), Klump and Polborn (2006), it was theoretically expected that in the period with no intermediate prize, a favorite player of the leading team would have a higher probability of winning than a favorite of the lagging team. In general, our results are in line with the theoretical prediction of the importance of strategic allocation of efforts in multi-stage contests. Although we cannot rule out the possibility of some other psychological effects, our findings suggest that an introduction of intermediate prizes may mitigate or even eliminate the ahead-behind effects that arise in multi-stage contests.

6 Conclusion

In this paper, we used a real tournament setting to test the effect of ahead-behind asymmetry on individuals' performance in multi-stage contests between teams with and without intermediate prizes. As previous studies, we also find that being ahead provides players with higher probability of success. However, the main contribution of this paper is that it empirically shows that intermediate prizes eliminate the usual ahead-behind effect that may arise from psychological as well as from strategic considerations.

Our results, obtained from real-life contests, emphasise the role of strategic motives in individual performance. This is especially important on the team level, because teamwork is probably the most prevalent way of economic activity. Our findings suggest that non-monetary incentives alone such as team's pride are probably not enough to maximise players' output. This result may be of high importance in situations that involve a choice between individual and society benefits.

It is also worth mentioning that individual incentives may improve the utility of other teammates, especially in a difficult situation for the whole team. This is because such incentives do not affect the winning probabilities of the leading favorites, who are likely to win the decisive match regardless of the incentives. It is rather the lagging favorites, and their teammates, who may benefit from the additional individual reward. This may explain why companies in difficulties are ready to pay extra salaries to certain individuals only, who however, may improve the situation of other workers by increasing the stability of their workplace.

Finally, it is important to note that despite the fact that our findings are in line with the common ahead-behind effects and with strategic neutrality, the results of this paper were obtained from the sport of tennis, which is mostly an individual sport. Playing within teams in Davis Cup is not the usual thing for most of the players. Therefore, it is possible that our results would be different in other settings, where agents are used to performing in teams. It is also possible that agents that are not used to high-monetary rewards, such as professional tennis players, would also behave differently. Therefore, we call for additional empirical research to test the interactive effect of intermediate prizes and ahead-behind asymmetry in various other environments.

7 References

Altonji, J.G., Elder, T.E. and Taber, C.R., 2005. Selection on observed and unobserved variables: Assessing the effectiveness of Catholic schools. *Journal of Political Economy*, 113(1), pp. 151-184.

Apesteguia, J. and Palacios-Huerta, I., 2010. Psychological pressure in competitive environments: Evidence from a randomized natural experiment. *The American Economic Review*, 100(5), pp. 2548-2564.

Ariely, D., Gneezy, U., Loewenstein, G. and Mazar, N., 2009. Large stakes and big mistakes. *The Review of Economic Studies*, 76(2), pp.451-469.

Berger, J. and Pope, D., 2011. Can losing lead to winning?. *Management Science*, 57(5), pp.817-827.

Cohen-Zada, D., Krumer, A., Rosenboim, M. and Shapir, O.M., 2017. Choking under pressure and gender: Evidence from professional tennis. *Journal of Economic Psychology*, 61, pp. 176-190.

Cohen-Zada, D. Krumer, A. and Shtudiner, Z., 2017. Psychological momentum and gender. *Journal of Economic Behavior and Organization*, 135, pp. 66-81.

Dohmen, T. and Falk, A., 2011. Performance pay and multidimensional sorting: Productivity, preferences, and gender. *The American Economic Review*, 101(2), pp.556-590.

Ehrenberg, R.G. and Bognanno, M.L., 1990. Do tournaments have incentive effects?. *Journal of Political Economy*, 98(6), pp.1307-1324.

Erev, I., Bornstein, G. and Galili, R., 1993. Constructive intergroup competition as a solution to the free rider problem: A field experiment. *Journal of Experimental Social Psychology*, 29(6), pp.463-478.

Eurofound, 2014. Working conditions and job quality: Comparing sectors in Europe, Dublin.

Fu, Q., Lu, J. and Pan, Y., 2015. Team contests with multiple pairwise battles. *The American Economic Review*, 105(7), pp.2120-2140.

Genakos, C. and Pagliero, M., 2012. Interim rank, risk taking, and performance in dynamic tournaments. *Journal of Political Economy*, 120(4), pp.782-813.

Genakos, C., Pagliero, M. and Garbi, E., 2015. When pressure sinks performance: Evidence from diving competitions. *Economics Letters*, 132, pp.5-8.

Gill, D. and Prowse, V., 2012. A structural analysis of disappointment aversion in a real effort competition. *The American Economic Review*, 102(1), pp.469-503.

González-Díaz, J., Gossner, O. and Rogers, B.W., 2012. Performing best when it matters most: Evidence from professional tennis. *Journal of Economic Behavior & Organization*, 84(3), pp. 767-781.

González-Díaz, J. and Palacios-Huerta, I., 2016. Cognitive performance in competitive environments: Evidence from a natural experiment. *Journal of Public Economics*, 139, pp. 40-52.

Harris, C. and Vickers, J., 1987. Racing with uncertainty. *The Review of Economic Studies*, 54(1), pp. 1-21.

Hart, S., 2005. An Interview with Robert Aumann. *Macroeconomic Dynamics*, 9(05), pp. 683-740.

Huber, M., Lechner, M. and Steinmayr, A., 2015. Radius matching on the propensity score with bias adjustment: tuning parameters and finite sample behaviour. *Empirical Economics*, 49(1), pp. 1-31.

Huber, M., Lechner, M. and Wunsch, C., 2013. The performance of estimators based on the propensity score. *Journal of Econometrics*, 175(1), pp. 1-21.

Jetter, M. and Walker, J.K., 2015. Game, set, and match: Do women and men perform differently in competitive situations?. *Journal of Economic Behavior & Organization*, 119, pp.96-108.

Jetter, M. and Walker, J. K., 2017. Good Girl, Bad Boy? Evidence Consistent with Collusion in Professional Tennis. *Southern Economic Journal*. doi:10.1002/soej.12213

Kahn, L.M., 2000. The sports business as a labor market laboratory. *The Journal of Economic Perspectives*, 14(3), pp. 75-94.

Klaassen, F.J. and Magnus, J.R., 2001. Are points in tennis independent and identically distributed? Evidence from a dynamic binary panel data model. *Journal of the American Statistical Association*, 96(454), pp.500-509.

Klumpp, T. and Polborn, M.K., 2006. Primaries and the New Hampshire effect. *Journal of Public Economics*, 90(6), pp. 1073-1114.

Koning, R.H., 2011. Home advantage in professional tennis. *Journal of Sports Sciences*, 29(1), pp. 19-27.

Konrad, K.A. and Kovenock, D., 2009. Multi-battle contests. *Games and Economic Behavior*, 66(1), pp.256-274.

Krumer, A. and Lechner, M., 2017. First In First Win: Evidence on Schedule Effects in Round-Robin Tournaments in Mega-Events. *European Economic Review,* 100, pp.412-427.

Krumer, A., Megidish, R. and Sela, A., 2016. Round-Robin Tournaments with a Dominant Player. *The Scandinavian Journal of Economics*, doi: 10.1111/sjoe.12204.

Krumer, A., Megidish, R. and Sela, A., 2017. First-mover advantage in round-robin tournaments. *Social Choice and Welfare*, 48(3), pp.633-658.

Lazear, E.P., 2000. The power of incentives. *The American Economic Review*, 90(2), pp.410-414.

Lechner, M., Miquel, R. and Wunsch, C., 2011. Long-run effects of public sector sponsored training in West Germany. *Journal of the European Economic Association*, 9(4), pp. 721-784.

Malueg, D.A. and Yates, A.J., 2010. Testing contest theory: evidence from best-of-three tennis matches. *The Review of Economics and Statistics*, 92(3), pp. 689-692.

Oster, E., 2016. Unobservable selection and coefficients stability: Theory and Evidence. *Journal of Business and Economic Statistics*, forthcoming.

Palacios-Huerta, I., 2003. Professionals play minimax. *The Review of Economic Studies*, 70(2), pp.395-415.

Palacios-Huerta, I., 2014. Psychological pressure on the field and elsewhere. Chapter 5 in Beautiful game theory: How soccer can help economics. Princeton University Press.

Paserman, M.D., 2010. Gender Differences in Performance in Competitive Environments? Evidence from Professional Tennis Players, mimeo.

Pope, D.G. and Schweitzer, M.E., 2011. Is Tiger Woods loss averse? Persistent bias in the face of experience, competition, and high stakes. *The American Economic Review*, 101(1), pp.129-157.

Rosen, S., 1986. Prizes and incentives in elimination tournaments. *The American Economic Review*, 76(4), pp. 701-715.

Sheremeta, R.M., 2017. Behavior in group contests: A review of experimental research. *Journal of Economic Surveys*, doi: 10.1111/joes.12208.

Tsoulouhas, T., Knoeber, C.R. and Agrawal, A., 2007. Contests to become CEO: incentives, selection and handicaps. *Economic Theory*, 30(2), pp.195-221.

Van Dijk, F., Sonnemans, J. and Van Winden, F., 2001. Incentive systems in a real effort experiment. *European Economic Review*, 45(2), pp.187-214.

Walker, M. and Wooders, J., 2001. Minimax play at Wimbledon. *The American Economic Review*, 91(5), pp.1521-1538.

Table 1: Descriptive statistics

	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation
Variable Name	***Favorite is lagging***		***Draw***		***Favorite is leading***	
Favorite Wins	0.681	0.466	0.741	0.438	0.804	0.396
DiffRank=$\log_2$ (Favorite Rank)- $\log_2$ (Underdog Rank)	-1.540	1.307	-1.687	1.427	-1.847	1.476
DiffH2H=Head to Head Wins Favorite- Head to Head Wins Underdog	0.204	1.286	0.146	0.993	0.302	1.128
Home Advantage to Favorite	0.437	0.496	0.511	0.500	0.590	0.492
World Group	0.361	0.481	0.357	0.479	0.337	0.473
Group 1	0.291	0.455	0.311	0.463	0.315	0.465
Group 2	0.348	0.477	0.332	0.471	0.347	0.476
Last 16	0.124	0.330	0.122	0.327	0.110	0.313
Quarterfinal	0.203	0.402	0.202	0.401	0.205	0.404
Semifinal	0.231	0.422	0.224	0.417	0.209	0.407
Final	0.155	0.362	0.179	0.384	0.196	0.397
Playoff	0.231	0.422	0.222	0.416	0.236	0.425
Playoff in Group 2	0.057	0.233	0.052	0.222	0.043	0.203
World Group before 2009	0.178	0.383	0.162	0.369	0.144	0.351
World Group after 2009	0.183	0.387	0.195	0.396	0.194	0.395
Observations	646		1,037		764	

Table 2: Propensity score estimation

	(1)	*(2)*	*(3)*	*(4)*
	Favorite is lagging		***Favorite is leading***	
DiffRank	0.021***	0.022***	-0.019***	-0.023***
	(0.007)	(0.007)	(0.006)	(0.007)
DiffH2H	0.002	0.002	0.020**	0.021**
	(0.008)	(0.008)	(0.008)	(0.008)
Home Advantage to Favorite	-0.081***	-0.082***	0.090***	0.091***
	(0.018)	(0.018)	(0.018)	(0.018)
Group 1		-0.061*		0.072*
		(0.035)		(0.038)
Group 2		-0.042		0.072**
		(0.032)		(0.035)
Last 16		-0.037		0.048
		(0.054)		(0.059)
Quarterfinal		-0.047		0.054
		(0.049)		(0.054)
Semifinal		-0.031		0.034
		(0.044)		(0.049)
Final		-0.074*		0.073
		(0.045)		(0.049)
Playoff		-0.046		0.074
		(0.047)		(0.052)
World Group after 2009		-0.046		0.034
		(0.037)		(0.039)
Year dummies	No	Yes	No	Yes
Observations	2,447	2,447	2,447	2,447

Note: Logit average marginal effects are presented. In columns 1 and 2 the dependent variable is a dummy of whether a favorite is lagging. In columns 3 and 4 the dependent variable is a dummy of whether a favorite is leading. Standard errors are presented in parentheses. *, **, *** denote significance at the 10%, 5%, 1% level, respectively.

Table 3: The effects of lagging/leading on the probability to win a match

	Radius matching		*LPM*		*Oster*
	(1)	*(2)*	*(3)*	(4)	*(5)*
Panel A					
Favorite is lagging	-0.049***	-0.050**	-0.087***	-0.049**	-0.037*
	(0.019)	(0.022)	(0.022)	(0.020)	(0.020)
Number of obs.	2,447	2,447	2,447	2,447	2,447
Obs. in common support	2,439	2,441			
Panel B					
Favorite is leading	0.037*	0.054***	0.087***	0.048***	0.036**
	(0.018)	(0.020)	(0.018)	(0.017)	(0.018)
Number of obs.	2,447	2,447	2,447	2,447	2,447
Obs. in common support	2,426	2,440			
No controls	N	N	Y	N	Y
Basic controls	Y	N	N	N	N
Full specification	N	Y	N	Y	Y

Notes: The dependent variable is a dummy of whether a favorite wins in the respective match. In columns 1 and 2 the radius matching average effects of lagging/leading on the winning probability of a favorite are presented. The results in columns 1 and 2 of Panel A are based on the propensity score estimation presented in columns 1 and 2 of Table 2 respectively. The results in columns 1 and 2 of Panel B are based on the propensity score estimation presented in columns 3 and 4 of Table 2 respectively. Inference for the average treatment effect in columns 1 and 2 is based on bootstrapping the t-statistic (499 replications). The standard errors obtained from the bootstraps are presented in parentheses. For these columns we also present the number of observations in common support.

The list of basic controls includes the difference in ranking indexes between a favorite and an underdog, whether a favorite has a home advantage, and the difference in the previous head to head results as presented in columns 1 and 3 of Table 2. The full specification is presented in columns 2 and 4 of Table 2.

In columns 3 and 4 the coefficients from the LPM are presented. Standard errors clustered at the tie level are presented in parentheses.

In Column 5 we report Oster's bias-adjusted treatment effect when the amount of selection on unobservables is recovered from the amount of selection on all observables. Standard errors in Column 5 are obtained from bootstrapping (499 replications).

*, **, *** denote significance at the 10%, 5%, 1% level respectively.

Table 4: The effects of leading in asymmetric score

	Radius matching		*Oster*	
	(1)	*(2)*	*(3)*	(4)
	Match 2	***Match 4***	***Match 2***	**Match 4**
Favorite is leading	0.031	0.097**	0.024	0.106***
	(0.035)	(0.044)	(0.029)	(0.037)
Number of obs.	845	565	845	565
Obs. in common support	837	562		

Notes: The dependent variable is a dummy of whether a favorite wins in the respective match. In columns 1 and 2 the radius matching average effects of leading on the winning probability of a favorite are presented. The results in columns 1 and 2 are based on the propensity score estimation presented in columns 1 and 2 of Table B.1 respectively. Inference for the average treatment effect is based on bootstrapping the t-statistic (499 replications). The standard errors obtained from the bootstraps are presented in parentheses. For these columns we also present the number of observations in common support.
In column 3 and 4 we report Oster's bias-adjusted treatment effect when the amount of selection on unobservables is recovered from the amount of selection on all observables based on same specifications as in Table 3. Standard errors in these columns are obtained from bootstrapping (499 replications).
*, **, *** denote significance at the 10%, 5%, 1% level respectively.

Table 5: The effects of leading in match 4 in the World Group before and after 2009

	Radius matching		*Oster*	
	(1)	*(2)*	*(3)*	(4)
	Before 2009	***After 2009***	***Before 2009***	**After 2009**
Favorite is leading	0.222*	0.137	0.181	0.066
	(0.117)	(0.093)	(0.114)	(0.091)
Number of obs.	89	111	89	111
Obs. in common support	86	100		

Notes: The dependent variable is a dummy of whether a favorite wins in the respective match. In columns 1 and 2 the radius matching average effects of leading on the winning probability of a favorite are presented. The results in columns 1 and 2 are based on the propensity score estimation presented in columns 1 and 2 of Table D.1 respectively. Inference for the average treatment effect is based on bootstrapping the t-statistic (499 replications). The standard errors obtained from the bootstraps are presented in parentheses. For these columns we also present the number of observations in common support.
In columns 3 and 4 we report Oster's bias-adjusted treatment effect. We treat the variables that were significant in the propensity score estimation presented in Table D.1 as part of the identification strategy and thus recover the amount of selection on unobservables from the amount of selection on all the other observed characteristics. Therefore, in Column 3, the DiffRank and Year 2008 are included both in the controlled and uncontrolled regressions. In Column 4, the DiffRank is included both in the controlled and uncontrolled regressions. The results of these regressions are presented in Table E.1. Standard errors are obtained from bootstrapping (499 replications).
*, **, *** denote significance at the 10%, 5%, 1% level respectively.

Table 6: The effects of intermediate prize on the probability to win match 4 by a lagging favorite

	Radius matching	*LPM*		*Oster*
	(1)	*(2)*	(3)	*(4)*
After 2009	0.176	0.202**	0.202*	0.202*
	(0.113)	(0.099)	(0.103)	(0.111)
Number of obs.	89	89	89	89
Obs. in common support	87			
No controls	N	Y	N	Y
Full specification	Y	N	Y	Y

Notes: The dependent variable is a dummy of whether a favorite that was lagging before match 4 wins in the respective match. In Column 1 the radius matching average effect of post-2009 period on the winning probability of a favorite is presented. This result is based on the propensity score estimation presented in Appendix F, where we use the full specification. Inference for the average treatment effect in Column 1 is based on bootstrapping the t-statistic (499 replications). The standard errors obtained from the bootstraps are presented in parentheses. For Column 1 we also present the number of observations in common support.
In columns 2 and 3 the coefficients from the LPM are presented. Robust standard errors are presented in parentheses.
In Column 4 we report Oster's bias-adjusted treatment effect when the amount of selection on unobservables is recovered from the amount of selection on all observables. Standard errors in Column 4 are obtained from bootstrapping (499 replications).
*, **, *** denote significance at the 10%, 5%, 1% level respectively.

Appendix A: List of sources

www.daviscup.com

www.atpworldtour.com

www.itftennis.com

www.tennisabstract.com

www.tennis-data.co.uk

www.bet365.com/extra/en/betting/tennis

www.tennisbetsite.com

www.tennisexplorer.com

Appendix B: Propensity score estimation for matches 2 and 4

Table B.1 Propensity score estimation for matches 2 and 4

	(1) ***Match 2***	*(2)* ***Match 4***
DiffRank	-0.032*** (0.012)	-0.067*** (0.017)
DiffH2H	0.000 (0.017)	0.017 (0.016)
Home Advantage to Favorite	0.170*** (0.032)	0.111*** (0.039)
Group 1	0.099 (0.068)	0.149* (0.080)
Group 2	0.050 (0.062)	0.145** (0.072)
Last 16	0.063 (0.105)	0.104 (0.127)
Quarterfinal	0.083 (0.095)	0.103 (0.114)
Semifinal	0.060 (0.085)	0.056 (0.103)
Final	0.067 (0.086)	0.216** (0.105)
Playoff	0.097 (0.091)	0.103 (0.109)
World Group after 2009	0.022 (0.071)	0.120 (0.084)
Year dummies	Yes	Yes
Observations	845	565

Note: Logit average marginal effects are presented. The dependent variable is a dummy of whether a favorite is leading in the respective match. Standard errors are presented in parentheses. *, **, *** denote significance at the 10%, 5%, 1% level, respectively.

Appendix C: Comparison between the effects of leading

Table C.1: Comparison between the effects of leading in matches 2 and 4

	LPM		*Oster*
	(1)	*(2)*	*(3)*
Favorite is leading in match 4	0.099**	0.094**	0.092**
	(0.047)	(0.045)	(0.044)
Number of obs.	1,410	1,410	1,410
Main effects	Y	Y	Y
Full specification	N	Y	Y

Notes: The dependent variable is a dummy of whether a favorite wins in the respective match. In column 1 we present the results of the LPM controlling for main effects only (a dummy of whether a favorite is leading and a dummy of whether a match is match 4 or not (match 2)). In column 2 we use our full set of controls as presented in Column 4 of Table 3. Robust standard errors are presented in parentheses.

In column 3 we report Oster's bias-adjusted treatment effect. We treat the main effects as part of the identification strategy and thus recover the amount of selection on unobservables from the amount of selection on all the other observed characteristics, where the main effects are included both in the uncontrolled and controlled regressions presented in columns 1 and 2 respectively. Standard errors are obtained from bootstrapping (499 replications).

*, **, *** denote significance at the 10%, 5%, 1% level respectively.

Appendix D: Propensity score estimation for match 4

Table D.1 Propensity score estimation in match 4 in the World Group before and after 2009

	(1) **Before 2009**	*(2)* **After 2009**
DiffRank	-0.088***	-0.071**
	(0.034)	(0.035)
DiffH2H	0.002	0.026
	(0.035)	(0.026)
Home Advantage to Favorite	0.155	-0.052
	(0.101)	(0.096)
Last 16	0.010	0.085
	(0.127)	(0.108)
Quarterfinal	0.068	0.156
	(0.157)	(0.132)
Semifinal	-0.067	0.029
	(0.170)	(0.185)
Final	0.214	-0.193
	(0.234)	(0.235)
Year 2004	0.041	
	(0.177)	
Year 2005	0.125	
	(0.168)	
Year 2006	0.144	
	(0.182)	
Year 2007	0.123	
	(0.168)	
Year 2008	0.332*	
	(0.173)	
Year 2010		-0.088
		(0.184)
Year 2011		0.063
		(0.171)
Year 2012		-0.019
		(0.170)
Year 2013		0.017
		(0.167)
Year 2014		0.034
		(0.174)
Year 2015		0.052
		(0.160)
Observations	89	111

Note: Logit average marginal effects are presented. The dependent variable is a dummy of whether a favorite is leading in the respective match. Standard errors are presented in parentheses. *, **, *** denote significance at the 10%, 5%, 1% level, respectively.

Appendix E: Additional results for match 4 in the World Group

Table E.1. The effect of leading in match 4 in the World Group before and after 2009

	LPM		*Oster*
	(1)	(2)	*(3)*
Panel A: Before 2009			
Favorite is leading	0.178*	0.180*	0.181
	(0.095)	(0.091)	(0.114)
Number of obs.	89	89	89
Panel B: After 2009			
Favorite is leading	0.039	0.056	0.066
	(0.077)	(0.077)	(0.091)
Number of obs.	111	111	111
Controls from propensity score	Y	Y	Y
Full specification	N	Y	Y

Notes: In column 1 we present the results of the LPM controlling for variables that were significant in the propensity score estimation presented in Table D.1 as part of the identification strategy. Therefore, in Panel A, the *DiffRank* and *Year2008* are included both in the controlled and uncontrolled regressions. In Panel B, the *DiffRank* is included both in the controlled and uncontrolled regressions. Robust standard errors are presented in parentheses.
In column 3 we report Oster's bias-adjusted treatment effect that was also reported in Table 5. Standard errors are obtained from bootstrapping (499 replications).
*, **, *** denote significance at the 10%, 5%, 1% level respectively.

Appendix F: Propensity score estimation for post-2009 period

Table F.1 Propensity score estimation in match 4 in the World Group before and after 2009

DiffRank	0.028
	(0.046)
DiffH2H	0.033
	(0.030)
Home Advantage to Favorite	0.109
	(0.105)
Last 16	-0.064
	(0.126)
Quarterfinal	0.002
	(0.173)
Semifinal	-0.162
	(0.188)
Final	-0.137
	(0.245)
Observations	89

Note: Logit average marginal effects are presented. The dependent variable is a dummy of whether match 4 in which a favorite was lagging was played before or after 2009 (dummy equals one if the match is after 2009). Standard errors are presented in parentheses. *, **, *** denote significance at the 10%, 5%, 1% level, respectively.