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Gender Differences in Risk-Taking: Evidence from Professional Basketball *

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Abstract

We analyze gender differences in risk-taking in high-pressure situations. Using novel data from professional athletes (NBA and WNBA), we find that male teams increase their risk-taking towards the end of matches when a successful risky strategy could secure winning the match. Female teams, in contrast, reduce their risk-taking in these situations. The less time left in a match, the larger is the gap. When the costs of an unsuccessful risky strategy are very large (losing the tournament), we find no increase in risk-taking for male teams.

JEL Classification: D81, J16, L83

Keywords: Risk-taking, gender differences, tournament incentives

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1 Introduction

If women systematically make fewer risky choices than men, differences in risk-taking could cause gender differences in labor market outcomes (Gneezy and Rustichini, 2004), if risk-taking is considered a positive trait. Systematic differences in risk-taking between men and women could explain the gender wage gap and the underrepresentation of women in top-tier jobs (OECD, 2012; Weichselbaumer and Winter-Ebmer, 2005)

Empirical research typically finds that men take more risk than women (Croson and Gneezy, 2009; Eckel and Grossman, 2008). However, apart from laboratory or field experiments — where the manipulation of environmental parameters is possible —, there is limited evidence on the risk-taking of men and women. An exemption is the growing empirical literature on gender differences in portfolio choices on financial markets or pension funds (e.g. Säve-Söderbergh (2012)). Barber and Odean (2001) present evidence for gender differences in risk-taking using a large data set on investment decisions. They find that men do trade more frequently (i.e., they take more risk) than women, however at the cost of lower returns. A comprehensive survey on this strand of the literature is provided by Eckel and Füllbrunn (2015).

It is difficult to analyze risk-taking in the field because the available options are typically not restricted to a well-defined set, which makes the ex ante distinction between less risky and more risky (almost) impossible. Moreover, realized choices are the result of a combination of effort, information, and of risk preferences. These are typically not observed and, in general, we cannot infer from realized choices whether or not people differ in their risk preferences.

In sports, however, rules clearly define the set of options. In addition, in many situations the available options can be clearly ranked by their level of risk. Professional sports have strong incentive structures and rewards are linked to performance. We analyze differences in risk-taking in professional basketball, using data from male and female teams from 2002–14. Grund, Höcker and Zimmermann (2013) use the share of three-point attempts as an indicator of risk and they show that male basketball players increase risk-taking when they are trailing. We also use the share of three-point attempts of all shooting attempts as our indicator of risk-taking. In a first step, we examine if female

basketball players are also more likely to use risky strategies when they are trailing, which could be a first indicator for differences between male and female athletes.

The main contribution of our research is the analysis of gender differences in risk-taking in situations with clear differences in the costs and benefits of risky strategies. Since a basketball match lasts a limited time, the returns of risky choices change over the course of a match. Costs increase because a failed risky attempt has potentially more adverse consequences when the match is coming to an end than in situations where there is sufficient time to compensate for unsuccessful risky attempts. Similarly, a successful risky strategy at the final moment of a match might decide between winning or losing the match.[1]

We also investigate if risk-taking of female and male teams is affected by the relative importance of losing a match in a series of matches. The series are multiple interactions within elimination tournaments (typically, best-of-5, or best-of-7) and losing a match has different implications if a team is trailing, has won as many matches as the opponent or if it is ahead in wins in the play-off series. There are no studies on gender differences in risk-taking of professional athletes and their relative position in a competition, i.e., whether they are currently leading or trailing. The available evidence indicates that male athletes take more risk when they are trailing (Genakos and Pagliero, 2012; Grund and Gürtler, 2005; Grund et al., 2013) and that they reduce risk when they are leading (Ozbeklik and Smith, 2014).

Risk-taking behavior in competitive contests has been the focus of several theoretical contributions. Cabral (2003) analyzes how two agents decide between a safe and a risky technology depending on whether they are trailing or leading in a R&D contest. Risk is modeled as a mean preserving spread and, in equilibrium, the decision maker who is trailing chooses the risky technology, while the decision maker who is leading opts for the safe strategy. In contrast, in Taylor's (2003) model of mutual fund tournaments, the fund manager who leads in a tournament chooses risky strategies, especially when the lead in the contest is large. Empirical analyzes of mutual funds data from 1984 to 1996 support

[1]For example, Villanova's Kris Jenkins hit a game-winning 3-pointer at the buzzer to win the 2016 NCAA championship.

this view. However, it is likely that most of the presented evidence is coming from male decision makers.

Similar to Grund et al. (2013), we find that male teams increase their risk-taking towards the end of matches when they are trailing by a small amount and a successful risky strategy could secure the winning of the match. Our key finding shows that female teams, in contrast, reduce their risk-taking in these situations. The less time left in a match, the larger is the gap. A detailed investigation shows however that this difference is the result of risk-taking in matches where the costs of an unsuccessful risky strategy are relatively lower. In situations where the costs of an unsuccessful risky strategy are large — losing the match and, in consequence, the round in the elimination tournament — we find no difference in risk-taking between male and female teams. One potential explanation for our results might be male overconfidence. If this were the reason for our findings, we would expect to observe a lower probability to throw successfully or to win the match. We do not find such evidence.

2 Data

We use play-by-play data from the playoff matches of the 2002/3 to 2013/14 seasons from the two major professional basketball leagues in the USA, the Women's National Basketball Association (WNBA) and the National Basketball Association (NBA). Both leagues operate under similar rules and represent the top-level of basketball competitions in the USA.

For all but one season during this period, there were 12 teams competing in the WNBA and 30 teams in the NBA. In both leagues, a season consists of three phases — pre-season, a regular season, and the playoffs. During the pre-season, the teams compete in friendly matches, often against teams outside their league. The regular season is the first part in the championship. Each team in the NBA plays 82 matches against the other teams in the league, in the WNBA teams currently play 34 matches during the regular season. The best 8 teams in the WNBA and the best 16 teams in the NBA advance to the playoffs, which are structured as a pairwise elimination tournament with multiple interactions per stage. These tournaments consist of three (four) rounds in the WNBA

(NBA). The winner of the final round is the champion. All rounds in the WNBA playoffs are best-of-3; since the 2005 season, the WNBA finals are decided in a best-of-5 series. In the NBA, all playoff rounds are won in best-of-7 contests; only the first round in 2002/3 was a best-of-5 tournament.

The dimensions of the baketball courts, including the placement and size of the baskets, are the same in the NBA and WNBA, but for the three-point distance. Until season 2013/14, the three point distance in the WNBA was approximately 6.25 meters. Since season 2013/14, this distance has been set at approximately 6.75 meters. The distance of the three point line in NBA matches is between 6.7 and 7.23 meters (the distance is not marked by a semicircle). In addition to a shorter distance to the basket, the circumference of the basketball is 2.54 cm smaller for the WNBA than for the NBA. Given these differences, women had a slight advantage in scoring a three-point attempt, particularly in seasons 2002/3–2012/13.

Following Grund et al. (2013), we use the option between two-point and three-point attempts to identify athletes' risk-taking. A two-point attempt is the attempt of a player to score (throw the ball through the opponents' hoop) from inside a dedicated area. A three-point attempt is a similar attempt but from the outside of this area.[2] Table 7 in the Appendix tabulates the absolute number of observed scoring attempts for all relevant time intervals. Both types of attempts are contested by specific defensive tactics. Ceteris paribus, the difficulty of any attempt will increase with the distance to the basket. Every attempt beyond the three-point line will be more difficult than any attempt inside the line.

The returns to risky strategies change during a match. Consider the final moment of a match where the attempting team is 1 or 2 points behind. We illustrate the changes of the expected probabilities of winning the match conditional on the score difference of [-2,-1] in Figure 1. A successful three-point attempt will result in a win of the match for the attempting team. A successful three-point attempt at an earlier moment will not result in a win of the match, but increase the probability of winning the match as the opponents will have time to score additional points. We can therefore conclude that the

[2]Another possibility to score is presented by free throws which are awarded after personal fouls or certain breaches of the rules. A successful free throw yields only one point.

expected returns of a successful three-point attempt monotonously increase during the course of the match.[3]

In contrast, a failed three-point attempt at the final moment of a match where the attempting team is 1 or 2 points behind results in losing the match, for certain. A failed attempt at an earlier moment during the match will not result in losing the match, but merely lower the probability of winning the match as both teams still have time to score additional points. The expected returns of a failed three-point attempt monotonously decrease during the course of the match.

Considering the less risky strategy, a successful two-point attempt at the final moment of a match where the attempting team is 1 or 2 points behind will either result in winning the match or result in a tie and go into overtime. The expected probability of winning the match is therefore lower for a successful two-point attempt than for a successful three-point attempt in this specific situation. However, the expected probability to win the match after a failed two-point attempt is zero, i.e., it does not differ to the expected returns of a failed three-point attempt.

3 Descriptive Results

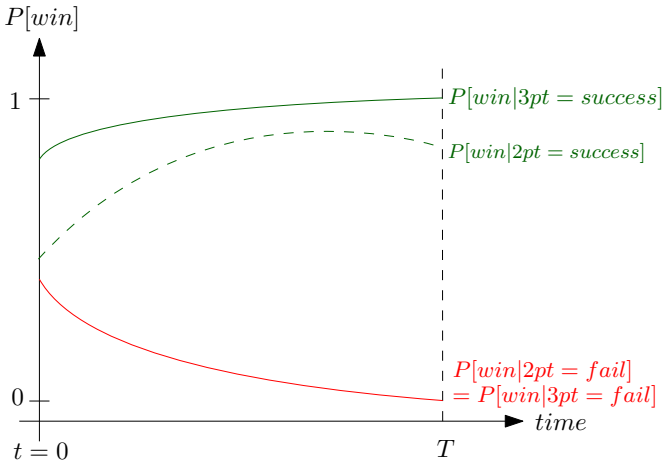
In Table 1 we tabulate the outcomes of two-point and three-point attempts for all attempts in our data, distinguishing between WNBA and NBA. The outcomes indicate that the probability of a successful three-point attempt is significantly lower than a successful two-point attempt (p-value < 0.001). Both attempts yield a similar expected score in both leagues, however, the variance of a three-point attempt is greater than for a two-point attempt. The only obvious difference between the WNBA and the NBA is that female players have a lower probability to convert a two-point attempt than men.[4] If we restrict the analysis to attempts within the last 60 seconds of the matches, the general pattern is the same as in Table 1.[5]

[3] We omit the last 5 seconds of every match, when there is little time for strategic considerations, from our analyses.

[4] This is most likely the result of the fact that male athletes are dunking the ball on a regular basis, while female athletes almost never do this.

[5] All tables are available on request.

Figure 1: Probability of winning a match if the team is trailing by 1 or 2 points, by attempt type.



Notes: Expected probability to win the match for a risky three-point success and fail versus a non-risky two-point success and fail over the course of a match (t=0 - T) at scoring differences -2 and -1. At t=T, the expected probability to win the match if a three-point attempt is successful is 1. The expected win probability of a successful two-point attempt at T is at 0.75 (1 if success is at score difference -1, and 0.5 if the successful throw is observed at -2, as both teams go into overtime and have a win probability of 0.5). Both, a failed two- and three-point attempt yield a win probability of 0.

Table 1: Attempts and outcomes, by gender.

	WNBA		*NBA*	
Points	*Attempt*		*Attempt*	
	2pt	**3pt**	**2pt**	**3pt**
0	**47.0**	**63.8**	**44.2**	**64.9**
1	5.7	0.1	6.2	0.1
2	**45.2**	0.2	**47.5**	0.3
3	2.1	**35.7**	2.0	**34.6**
4	0	0.2	0	0.2
Mean	1.023	1.085	1.073	1.051
SD	1.002	1.443	0.996	1.431
N	20,329	5,281	115,890	28,450

Notes: Points scored are given as percentages resulting from either two- or three-point attempts. Numbers in bold typeface are most relevant in terms of relative frequency and are achieved without points from potential free throws resulting from a penalty. Numbers in regular typeface include points obtained from penalties.

Players could substitute the more risky three-point attempt with the less risky two-point attempt, in combination with a provoked penalty free-throw. Table 1 also tabulates

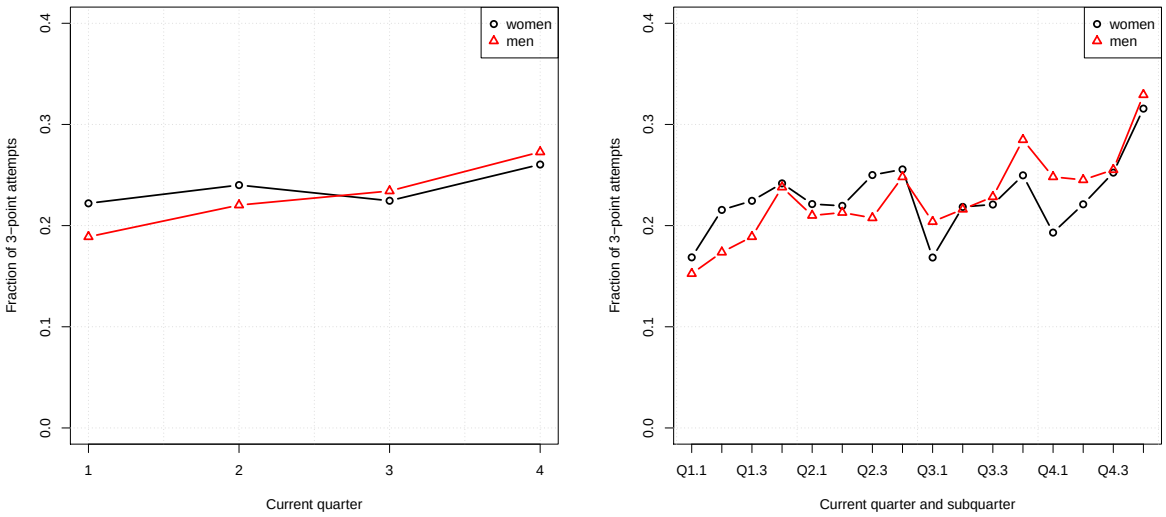
the frequency of a scores resulting from penalties. The frequency of this combination, two-point attempt with a successful penalty free-throw, is the same for men and women. This suggest that neither male nor female athletes substitute risk-taking by a more physical style of play.

Women attempted risky shots more often than men. In the WNBA, 23.6 percent of all attempts and 22.9 percent in the NBA were three-point attempts. In Figure 2, we plot the fraction of three-point attempts of all attempts for different match periods, separately for the NBA and the WNBA. For both leagues, three-point attempts vary over time and become more frequent towards the end of matches. In the WNBA there are relatively more three-point attempts than in the NBA during the first half of matches, but this is reversed in the second half, where there are relatively more three-point attempts in the NBA than in the WNBA.

Men increase the frequency of three-point attempts rate towards the end of any quarter more than women. This might be caused by differences in risk preferences. Another explanation could be differences in physical and/or psychological exhaustion. For example, if men tire more than women during the course of a match, tired players might avoid one-against-one situations and therefore attempt relatively more three-point attempts. Alternatively, differences in the tactical discipline of the players may shrink with fatigue and/or the time since the last coach intervention.

Score differences could be important for risk-taking. Figure 3 plots the fraction of three-point attempts of all attempts by the score differences before the attempt. (We plot averages of various bins on the right hand side of the diagram to improve readability.) Negative score differences indicate that the team was trailing. In general, we observe a U-shaped association between the likelihood of a three-point attempt and the score difference. The greater the absolute score difference, the more likely both men and women attempt a three-point shot. However, positive score differences are associated with women attempting three-point attempts less often than men, and negative score differences are associated with women attempting three-point attempt more often than men. This pattern is more pronounced in the last quarter of matches, where the probability of a three-point attempt is lower for score differences slightly greater than zero than for score differences

Figure 2: Three-point attempts as a fraction of all attempts in playoff matches, by gender and match time.



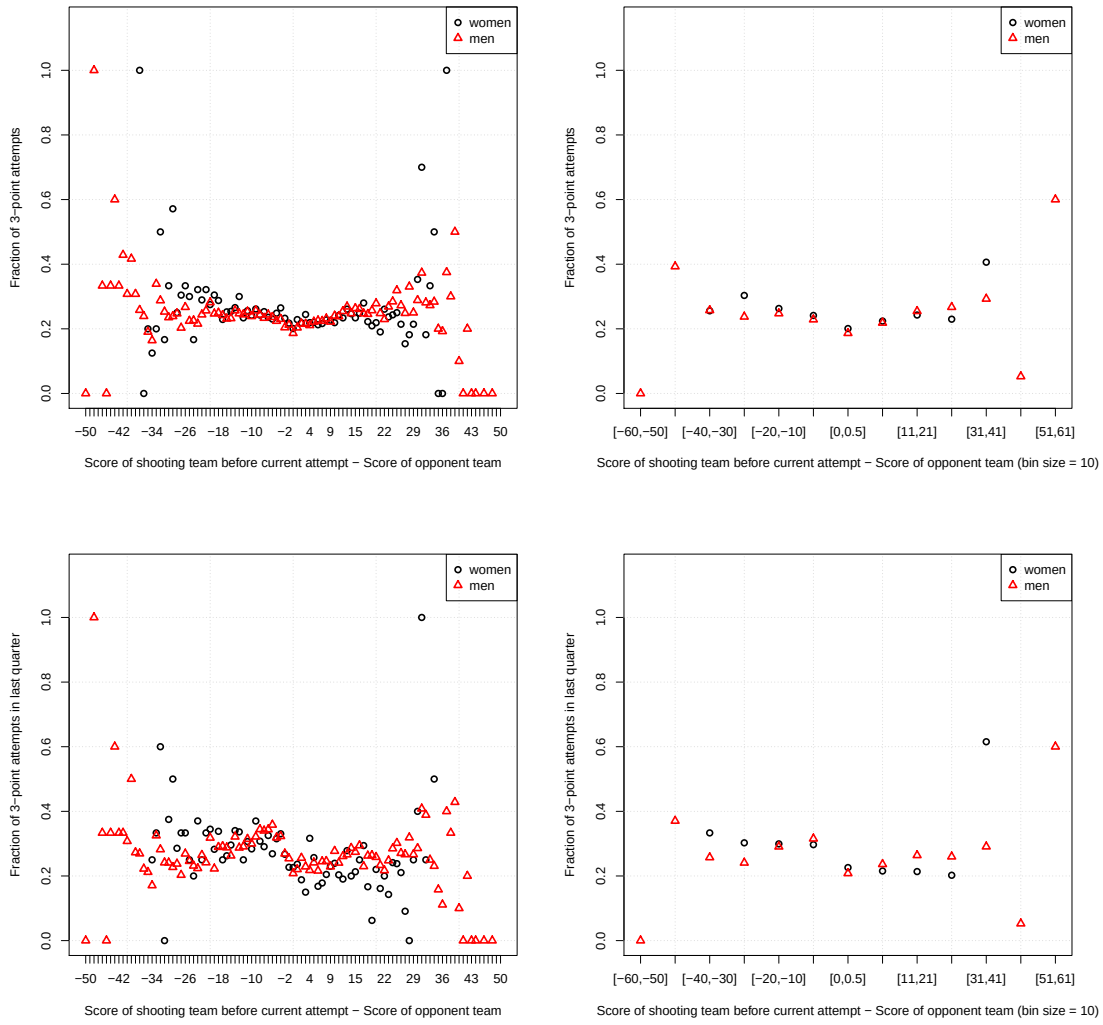
Notes: Fraction of three-point attempts among all two-point and three-point attempts in playoff matches, by match time and league. Overtime periods are included in Quarter 4.

slightly below zero. These are situations where a successful three-point attempt would change the relative position of teams.

In order to illustrate the tournament dynamics of the W/NBA playoffs, Figure 4 plots the fraction of three-point attempts of all attempts, stratified by the current playoff standings. The playoff standings are indicated by $x : y$, where x indicates the number of wins required for the shooting team and y indicates the number of wins required by the other team. If the shooting team needs fewer matches to win the playoff series than its opponent, then three-point attempts are more likely than if the playoff series are tied or if the shooting team has to catch up. We interpret this pattern by suggesting that three-point attempts are more frequent if the cost for missed attempts is comparatively low. Although this pattern is evident for both male and female leagues, men choose risk-taking more than women in case of a clear lead.

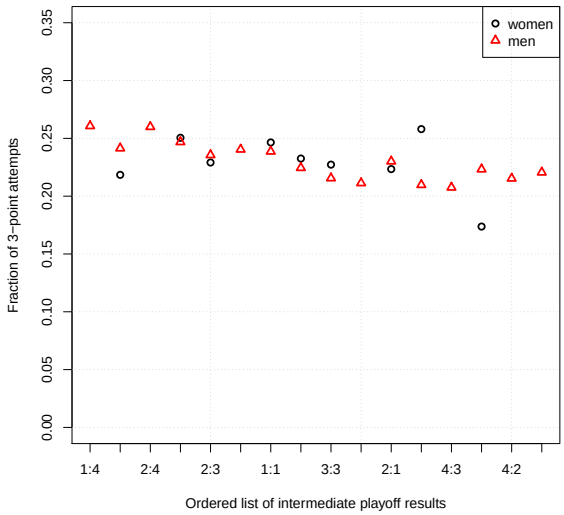
Figure 5 plots the fraction of successful three-point attempts among three-point attempts by quarters and sub-quarters. Overall, female teams are only slightly more successful with three-point attempts (35.4) than male teams (34.7). Regarding two-point

Figure 3: Probability of a shot being a three-point attempt for all observed scoring differences.



Notes: Upper panel: all quarters. Lower panel: Fourth quarter only. Positive differences represent score attempts of the leading team. Negative differences represent score attempts of the trailing team. Overtime periods are included in Quarter 4.

Figure 4: Three-point attempts as a fraction of all attempts over current playoff standings.



Notes: Fraction of three-point attempts of all attempts by current standing in playoff series, indicated by $x : y$. The first number in the socre, x, gives the number of wins which are required for the team of the shooting player to win the playoff round. The second number, y, states the number of required wins for the opponents.

attempts, male players are more successful than female players (not shown in graph). In our data, WNBA players have a two-point success probability of 44.5 percent and NBA player have a significantly higher probability of 47.1 percent (p-value < 0.001).

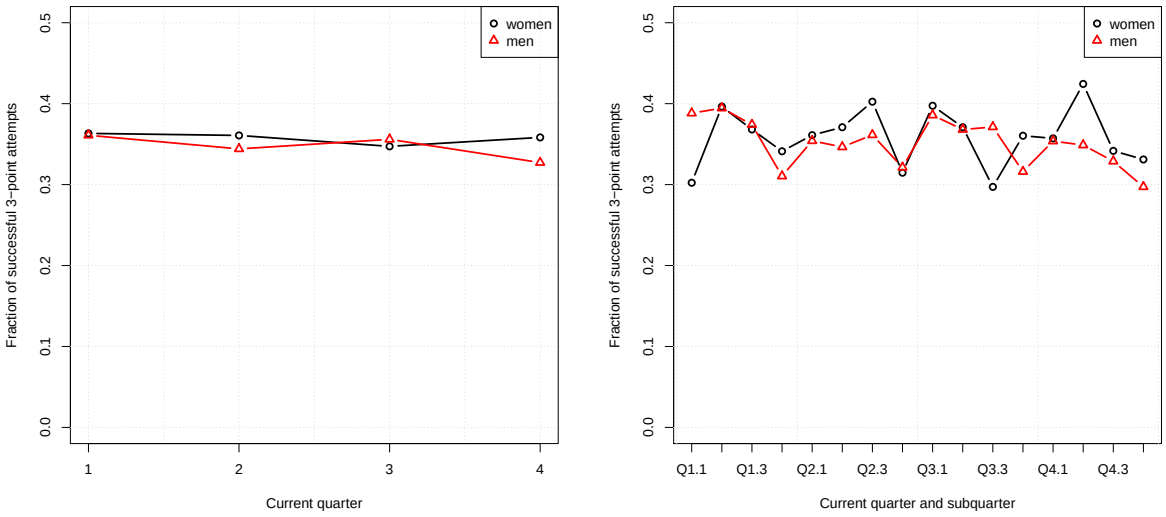
4 Empirical Strategy and Results

We analyze if risk-taking of female and male teams is affected by the relative costs of attempting a risky strategy. We estimate if an attempt i of team T during the period k and for a score-interval j was a three-point attempt or not:

$$\text{three-point attempt}_i = \beta_0 + \sum_{k=1}^{13} \gamma_k S_k + \sum_{k=1}^{14} \delta_k^j \psi_j S_k + \mathbf{X}_i' \pi + \xi_{\mathbf{T}} + \epsilon_i, \tag{1}$$

where the dependent variable is a binary indicator which is equal to 1 if the attempt is a three-point attempt and 0 if it is a two-point attempt. S is a vector of indicator variables

Figure 5: Fraction of successful three-point attempts, by quarter and sub-quarter.



Notes: Left panel: fraction of successful three-point attempts of total attempts in a given quarter. Right panel: fraction of successful three-point attempts of total attempts for given sub-quarters of quarters. Overtime periods are included in Quarter 4.

which detail the score difference from the perspective of team T. The γ_k give the change in the probability of a three-point attempt relative to the reference category, the interval $[0, 1]$, of being in a tied match or leading by one point. In order to capture changes towards the end of match time, ψ_j, is a binary indicator that indicates if the attempt is during the last minutes of a match. We estimate the equation separately for different ψ_j, where ψ_1 indicates if the attempt was during the last eight minutes of a match. The indicators ψ_2 indicates the last three minutes and ψ_3 indicates the final minute of a match. The coefficients δ_k^j, which measure the additional probability of an attempt being a three-point attempt when the score difference is in bracket k and in the time interval ψ_j, is our main interest here.

Additional control variables are in $\mathbf{X}$, where we include an indicator for home matches, indicators for the number of remaining wins (defeats) to win (lose) the playoff, and the three-point and two-point attempt success rates of the current match up to (but not including) to current attempt. We include fixed-effects ξ_T to control for unobserved heterogeneity on matches between the same opponents in a play-off round in a season, (team

× play-off round × season). Standard errors are clustered on (team × play-off round × season).

We tabulate the coefficients δ_k^j, the additional effect of the score differences during the final periods of a match, in Table 2 and plot the estimated coefficients in the bottom panel of Figure 6. In the top panel, we plot all γ_k, i.e., the estimated change in the probability of a three-point attempt relative to the reference category.

Overall, we estimate that teams which are behind are more likely to attempt a three-point attempt. In addition, this additional increase in the probability is greater during the last minutes of the match. Male teams seem to react more strongly than female teams, however, the differences are not statistically significant at conventional error levels.

We now consider situations where teams are trailing by one or two points, i.e., a successful three-point attempt would put the team into the lead. We do not estimate any difference between NBA and WNBA teams when we consider the last eight minutes of a match. The less time left in a match, however, the more are male teams likely to attempt risky shots, relative to the time before the interval under consideration. In contrast, female teams *reduce* the probability of risky shots when they trail by one or two points towards the end of a match. We find the strongest difference for the last minute of a match. During the final minutes of a match, we find little evidence for increased risk-taking when teams lead.

The results for male teams correspond to evidence presented by Grund et al. (2013), however, the results for female teams differ. We find evidence for a gender difference in risk-taking in decisive moments of a match which increases as the relative gains from a successful risky strategy (and the relative costs of an unsuccessful risky attempt) increase.

Table 2: Estimated effect of score difference on the probability of a three-point attempt.

	Attempt was during the					
	last 8 minutes		**last 3 minutes**		**last minute**	
Score	**WNBA**	**NBA**	**WNBA**	**NBA**	**WNBA**	**NBA**
[-60, -20)	0.042	0.007	-0.029	0.008	-0.024	0.012
	(0.046)	(0.015)	(0.058)	(0.02)	(0.095)	(0.031)
[-20, -10)	0.064***	0.086***	0.139***	0.113***	0.198***	0.123***
	(0.023)	(0.009)	(0.034)	(0.015)	(0.049)	(0.021)
[-10, -8)	0.113***	0.106***	0.199***	0.184***	0.294***	0.306***
	(0.032)	(0.016)	(0.05)	(0.024)	(0.06)	(0.034)
[-8, -6)	0.104***	0.139***	0.171***	0.229***	0.322***	0.335***
	(0.034)	(0.014)	(0.052)	(0.021)	(0.078)	(0.03)
[-6, -4)	0.094***	0.147***	0.143***	0.257***	0.238***	0.401***
	(0.028)	(0.014)	(0.044)	(0.022)	(0.069)	(0.027)
[-4, -2)	0.066**	0.104***	0.126***	0.154***	0.294***	0.24***
	(0.027)	(0.013)	(0.035)	(0.019)	(0.059)	(0.031)
[-2, 0)	0.019	0.05***	-0.007	0.082***	-0.094**	0.071**
	(0.022)	(0.012)	(0.033)	(0.019)	(0.045)	(0.029)
[0, 2)	0.04	0.023**	0.035	0.027	-0.056	0.022
	(0.026)	(0.011)	(0.032)	(0.017)	(0.054)	(0.028)
[2, 4)	-0.047*	0.033***	0.02	-0.008	-0.111*	0.006
	(0.024)	(0.012)	(0.042)	(0.017)	(0.059)	(0.029)
[4, 6)	0.089***	-0.008	0.129**	-0.032*	0.073	-0.033
	(0.033)	(0.012)	(0.058)	(0.018)	(0.103)	(0.036)
[6, 8)	-0.027	0.012	-0.02	-0.027	-0.151**	-0.021
	(0.035)	(0.014)	(0.069)	(0.021)	(0.07)	(0.044)
[8, 10)	-0.009	-0.006	-0.05	0.018	-0.045	0.007
	(0.03)	(0.016)	(0.045)	(0.026)	(0.098)	(0.054)
[10, 20)	-0.006	0.022**	-0.015	0.038**	0.06	0.103***
	(0.016)	(0.009)	(0.028)	(0.015)	(0.055)	(0.026)
[20, 60)	-0.01	0.01	0.03	-0.003	0.038	0.03
	(0.027)	(0.016)	(0.063)	(0.021)	(0.136)	(0.036)

Note: N=25,610 attempts in the WNBA and N=144,340 attempts in the NBA. The dependent variable is equal to 1 if the attempt is a three-point attempt and 0 if it is a two-point attempt. Score indicates the score difference from the attempting team's perspective. Coefficients for time indicators and additional control variables are not reported. All specifications include an indicator for home matches, the number of remaining wins (defeats) to win (lose) the playoff series, the three-point and two-point success rates up to the attempt, and team–play-off round–season fixed-effects. *, **, and *** indicate statistical significance at the 10 percent, 5 percent, and 1 percent level. Clustered standard errors (clustered for team–play-off round–season) in parentheses.

The relative importance of winning a match changes during the season in relation to the number of matches already won. During the regular season, the chances of reaching the playoffs for a team which has already won more matches than its competitors does not greatly depend on the win or loss of a particular match. During the playoffs, an elimination tournament with multiple interactions, each round of the tournament is decided by a series of matches. To win a round, a team in the WNBA needs to win 2 out of 3 matches, and a team in the NBA needs to win 4 of 7 matches. The winner of a round advances to the next round, until the champion of the season remains.

In order to analyze potential differences in the reaction of female and male teams in different playoff situations, we distinguish between three different situations during the playoffs. We stratify the sample according to whether a team is *trailing*, has a *tied* score or is *leading* in the number of won matches of the playoff series.

Table 3 presents the results of estimating equation (1) for the three different situations, controlling for varying time until the end of the match.[6] If a team is behind in a match by two or one points, we estimate that male teams increase risk-taking in matches where the series is ties or the team is in the lead. We estimate this increase in risk-taking for all durations until the end of the game, with a suggestion that this risk-taking increases the less time until the end. We do not estimate such an association in matches where the team is behind in the number of won matches in the series. For female teams, however, we estimate no increase in risk-taking. In contrast, we estimate a substantial decrease in risk-taking during the last minute in matches where the playoff series is tied and the team is slightly behind. We also estimate that female teams substantially reduce risk-taking during the last minute in matches where the team is behind in the playoff series and the score difference is 0 or 1. These estimates suggest that the choice of risky-strategies is influenced by the importance of winning the match and male teams increase risk-taking if the cost of losing the match is lower. (A potential loss of the match due to a failed risky strategy does not result in losing the playoff series.)

However, some of the matches, in particular for the WNBA, where teams need to win 2 of 3 matches, are pivotal, i.e., winning or losing determines the winner of the playoff series. We therefore repeat our estimates with sample where we exclude pivotal matches.

[6] Figure 7 plots the estimated coefficients.

The results are tabulated in Table 4. For these non-pivotal matches, we estimate that male teams increase risk-taking during the final minutes of a match when the team is behind by 2 or 1 points in matches where the team is leading in the series. In matches where the series are tied, male teams also increase their risk-taking during the final minutes of a match if it is slightly behind.

Because all but the finals after 2005 in the WNBA playoff series are best-of-3 tournaments, the number of attempts in non-pivotal matches where a team is leading or trailing is low.[7] We therefore restrict our analysis to matches where the series was tied. For these matches, we estimate that female teams reduce risk-taking if they are slightly behind during the final minutes of a match. Risk-taking is substantially less towards the end of a match.

In Table 5, we tabulate the estimated probabilities of a three-point attempt for the pivotal matches in the series. In contrast to the non-pivotal NBA matches, we estimate no significant increase in risk-taking during the final minute of a match. (Note that there are few pivotal matches which are tied, this is likely due to risk-taking earlier in the series.)

The results from Tables 3–5 suggest that male teams increase their risk-taking towards the end of matches when the score difference is -1 or -2 in non-pivotal matches. Female teams do not increase their risk-taking, in contrast, they appear to reduce it. We interpret these results that male teams seem to force a decision early in the series, when the potential costs of losing a match are relatively low. In the WNBA, most non-pivotal matches are in a tied series and the teams appear to avoid falling behind in the series by reducing risk-taking in matches where the score is close. When restricting all tied-series matches to non-pivotal tied-series matches which are technically best-of-3.[8] Although we lose significance due to the smaller sample, we still estimate a similar gender gap in risk taking as for all non-pivotal games when the overall series is tied. From this we can conclude that the tournament format is not responsible for the estimated gender gap in risk taking.

[7] The total number WNBA matches trailing (in lead) is 8 (8) with 19 (19) attempts during the last 8 minutes.

[8] For the NBA, a best-of-5 series which is tied at 1:1 as well as a best-of-7 series tied at 2:2 resembles a best-of-3 series, as each team only needs two additional wins to win the series. Similarly, for those WNBA finals which are best-of-5 we use all matches when the series is tied at 1:1.

Table 3: Estimated probability of a three-point attempt, by playoff standing and time to the end of the match.

		trailing		**tied**		**in lead**	
		WNBA	NBA	WNBA	NBA	WNBA	NBA
$t < 8$	[-2, 0)	0.033	0.02	-0.003	0.075***	0.061	0.051**
		(0.041)	(0.019)	(0.03)	(0.022)	(0.055)	(0.021)
N		81	500	201	526	79	526
	[0, 2)	0.066	0.016	0.028	0.03*	0.044	0.024
		(0.06)	(0.018)	(0.031)	(0.018)	(0.067)	(0.02)
N		76	586	215	559	78	545
$t < 3$	[-2, 0)	0.056	0.036	-0.046	0.118***	0.066	0.082***
		(0.058)	(0.032)	(0.043)	(0.032)	(0.09)	(0.03)
N		40	184	107	245	26	209
	[0, 2)	-0.006	0.041	0.048	0.020	0.022	0.024
		(0.079)	(0.029)	(0.040)	(0.028)	(0.077)	(0.03)
N		24	206	95	218	31	204
$t < 1$	[-2, 0)	-0.03	-0.002	-0.14***	0.106**	0.025	0.102*
		(0.091)	(0.043)	(0.053)	(0.045)	(0.158)	(0.056)
N		18	75	51	95	9	75
	[0, 2)	-0.21***	-0.04	-0.05	0.046	0.022	0.059
		(0.048)	(0.052)	(0.054)	(0.046)	(0.222)	(0.048)
N		5	60	41	83	8	71

Note: The dependent variable is equal to 1 if throwing attempt is a 3-point attempt. Coefficients for time indicator variables and additional control variables are not reported. All specifications include home match indicator, the number of remaining wins (defeats) to win (lose) the playoff series, the three-point and two-point success rates previous to the attempt and team-round-season indicators. *, **, and *** indicate statistical significance at the 10-percent level, 5-percent level, and 1-percent level. Standard errors clustered on team-round-year in parentheses.

Table 4: Additional probability of a three-point attempt by playoff standing for different time intervals. All playoff standings are restricted to those matches which are not potentially decisive.

		trailing	**tied**		**in lead**	**tied best-of-3**	
		NBA	WNBA	NBA	NBA	WNBA	NBA
$t < 8$	[-2, 0)	0.012	-0.023	0.076***	0.04*	0	0.081*
		(0.022)	(0.037)	(0.022)	(0.023)	(0.04)	(0.042)
N		332	119	514	371	96	105
$t < 8$	[0, 2)	0.017	0.016	0.022	0.025	0.053	0.031
		(0.022)	(0.038)	(0.018)	(0.025)	(0.041)	(0.042)
N		373	131	535	354	113	134
$t < 3$	[-2, 0)	0.039	-0.092*	0.118***	0.085**	-0.066	0.092*
		(0.041)	(0.056)	(0.033)	(0.038)	(0.05)	(0.05)
N		121	55	240	140	44	59
$t < 3$	[0, 2)	0.086**	0.074	0.014	0.035	0.109**	0.02
		(0.037)	(0.050)	(0.027)	(0.036)	(0.053)	(0.053)
N		126	58	209	144	50	66
$t < 1$	[-2, 0)	-0.018	-0.235***	0.115***	0.013*	-0.229***	0.151
		(0.049)	(0.02)	(0.045)	(0.065)	(0.023)	(0.094)
N		53	24	93	52	22	19
$t < 1$	[0, 2)	-0.019	-0.022	0.038	0.083	0.013	0.043
		(0.069)	(0.076)	(0.046)	(0.062)	(0.084)	(0.08)
N		40	22	81	47	19	25
# matches		366	79	283	366	71	57

Note: The dependent variable is equal to 1 if throwing attempt is a 3-point attempt. Coefficients for time indicator variables and additional control variables are not reported. All specifications include home match indicator, the number of remaining wins (defeats) to win (lose) the playoff series, the three-point and two-point success rates previous to the attempt and team-round-season indicators. *, **, and *** indicate statistical significance at the 10-percent level, 5-percent level, and 1-percent level. Standard errors clustered on team-round-year in parentheses. The total number WNBA matches trailing (in lead) is 8 (8) with 19 (19) attempts during the last 8 minutes.

Table 5: Additional probability of a three-point attempt by playoff standing for different time intervals. All playoff standings are restricted to those matches which are potentially decisive.

		trailing		**tied**		**in lead**	
		WNBA	NBA	WNBA	NBA	WNBA	NBA
$t < 8$	[-2, 0)	0.028	0.024	0.029	0.116	0.028	0.076*
		(0.039)	(0.036)	(0.052)	(0.095)	(0.055)	(0.044)
N		70	168	82	12	67	156
$t < 8$	[0, 2)	0.071	0.006	0.048	0.209*	0.019	0.017
		(0.066)	(0.031)	(0.052)	(0.124)	(0.061)	(0.031)
N		68	213	84	24	71	191
$t < 3$	[-2, 0)	0.064	0.019	-0.004	0.185	0.075	0.066
		(0.066)	(0.053)	(0.07)	(0.149)	(0.111)	(0.057)
N		36	63	52	5	21	69
$t < 3$	[0, 2)	0.012	-0.031	0.016	0.188	0.027	-0.003
		(0.078)	(0.041)	(0.065)	(0.195)	(0.078)	(0.053)
N		24	80	37	9	31	60
$t < 1$	[-2, 0)	0	0.02	-0.069	-0.22***	0.03	0.064
		(0.095)	(0.08)	(0.099)	(0.021)	(0.157)	(0.104)
N		16	22	27	2	9	23
$t < 1$	[0, 2)	-0.193***	-0.08	-0.081	0.33	0.028	-0.012
		(0.043)	(0.07)	(0.074)	(0.368)	(0.222)	(0.078)
N		5	20	19	2	8	24
#matches		74	200	37	31	74	200

Note: The dependent variable is equal to 1 if throwing attempt is a 3-point attempt. Coefficients for time indicator variables and additional control variables are not reported. All specifications include home match indicator, the number of remaining wins (defeats) to win (lose) the playoff series, the three-point and two-point success rates previous to the attempt and team-round-season indicators. *, **, and *** indicate statistical significance at the 10-percent level, 5-percent level, and 1-percent level. Standard errors clustered on team-round-year in parentheses. N denotes the number of attempts.

4.1 Success

Rational individuals, and teams, choose risky strategies because they expect the potentials gains to outweigh the potential costs. Our results so far indicate that NBA teams increase risk-taking towards the end of (non-pivotal) matches. A priori, it is not clear whether this is likely to result in more or fewer successful attempts. If this risk-taking is due to overconfidence, the success rate will decrease as the quality of the marginal attempt will be less than that of the average attempt. Alternatively, if the increase in risk-taking is due to critical ability in the presence of particularly high stakes (González-Díaz, Gossner and Rogers, 2012), the success rate of three-point attempts might even increase.

We estimate the probability of a successful three-point attempt and plot the results in Figure 8.[9] The changes in the success rates for close scores in the final minutes do not differ for men and women. We find — neither for men, nor for women — no evidence for differing success rates in close matches during the final minutes. Increased risk-taking does not appear to be the result of overconfidence or performance under pressure.

The success of a single attempt could also be measured by the probability to win the match. We estimate a linear probability model where the dependent variables is equal to 1 if the team wins the match, and 0 if it loses. The focus of this analysis is the rate of risk taking at the critical score interval of $[-2, 0)$, where we estimated the biggest gender gap in risk taking. In order to control for how close the match actually turned out, we include the absolute number of shooting attempts at this score difference as an additional control variable. Table 6 tabulates the estimated coefficients which measure the returns to increased risk-taking during the final minutes of a match.

We estimate a positive but insignificant coefficient for the three-point attempt rate at the critical score interval of $[-2, 0)$ for WNBA teams within the final three minutes and the final minute. For NBA teams, we estimate a negative and insignificant coefficient for the ratio of three-point attempts within the same intervals. Only for the longer period of the final 8 minutes of the game we measure an increase in the probability to win the game for WNBA teams as the increase risk taking when trailing by 2 or 1 points. For NBA teams, we measure a significant decrease in the probability to win the match. From these estimates we conclude that there is little evidence for a significant gender difference in match outcomes for male and female teams concerning risk taking in critical situations. However, there is some indication that NBA teams slightly reduce their chance to win the game if they increase risk taking when trailing, while WNBA seemingly increase their chances.

[9] All further results available upon request / available on an accompanying website.

Table 6: Match win probabilities for all matches.

	< 8		< 3		<1	
	WNBA	NBA	WNBA	NBA	WNBA	NBA
Percentage three-point attempts at [-2 0)[b]	0.185*	-0.130**	0.072	-0.084	0.262	-0.111
	(0.104)	(0.060)	(0.133)	(0.070)	(0.235)	(0.087)
Number of attempts at [-2 0)[b]	-0.028**	-0.012*	-0.051**	-0.030**	-0.123***	-0.071**
	(0.012)	(0.007)	(0.020)	(0.013)	(0.036)	(0.028)

The Dependent variable is equal to 1 if observed team wins the match. Coefficients for time dummies and additional control variables are not reported due to space limitations. All specifications include home match dummy, the number of remaining wins (defeats) to win (lose) the playoff series and team-season dummies. *, ** and *** indicate statistical significance at the 10-percent level, 5-percent level, and 1-percent level, respectively. Clustered standard errors (clustered for team-round-year) in round parentheses.

[b] All variables measured at score difference [-2 0).

5 Discussion and Conclusion

In our empirical analysis we provide evidence for the existence of a gender gap in the willingness to take risk. We construct a clear risk measure and evaluate the willingness of female and male professional athletes to incur risk in critical situations. We find this gap to be large and significant in situations where pressure to perform and potential consequences of failure are high. The higher these costs, i.e. the less time remains to compensate for a failed risky strategy, the larger is the gender gap in risk-taking. Our findings confirm earlier theoretical and empirical findings: male and female professional basketball teams use risky strategies to cover gaps. However, in more critical situations, male teams choose risky strategies, while female teams behave more risk averse.

We further explore the influence of the playoff tournament structure on risk taking in critical situations. We find that male teams increase risk-taking when they are leading the playoff series or when the series is tied. For female teams, however, we do not find such willingness to incur risk, as they stay conservative in crucial situations, regardless of the overall playoff standings. Consequently we measure a sizeable gender gap in risk-taking when teams have a higher probability to win the series than to lose it.

The dynamic tournament structure of professional basketball playoffs allows the analysis of pivotal and non-pivotal games. We estimate a gender gap in risk taking only in non-pivotal matches of tied playoff series, i.e., in matches where the observed team cannot win or lose the overall playoff series. This sizeable gender gap is not due to differences in WNBA and NBA playoff structures, as it stays persistent for matches with a tournament structure which is comparable across genders.

In terms of consequences of risk-taking, we provide evidence that success rates for men and women in the final minutes of the match with small score differences are not different for men and women.

Decisions to incur risk at during a match can be made by the players who then take the risky shot, or by the coach standing on the sidelines. Grund et al. (2013) argue that the increase in risk-taking they find is mostly ineffective and they attribute this to coaching decisions. In our analysis we cannot distinguish between decisions of coaches and players. As the observed gender gap in risk-taking could potentially be explained by female players as well as female coaches making the decision, future research on this issue is needed.

In contrast to other studies, which investigate single athletes (e.g., Gerdes and Gränsmark (2010)), we analyze teams of athletes who need to cooperate in order to win. This coordination, and the cooperation of the team with their coaches, might eliminate any gender differences that might be observed in competitions of individual athletes. Our results do not confirm this, as the gender gap is sizeable and significant.

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6 DATA APPENDIX

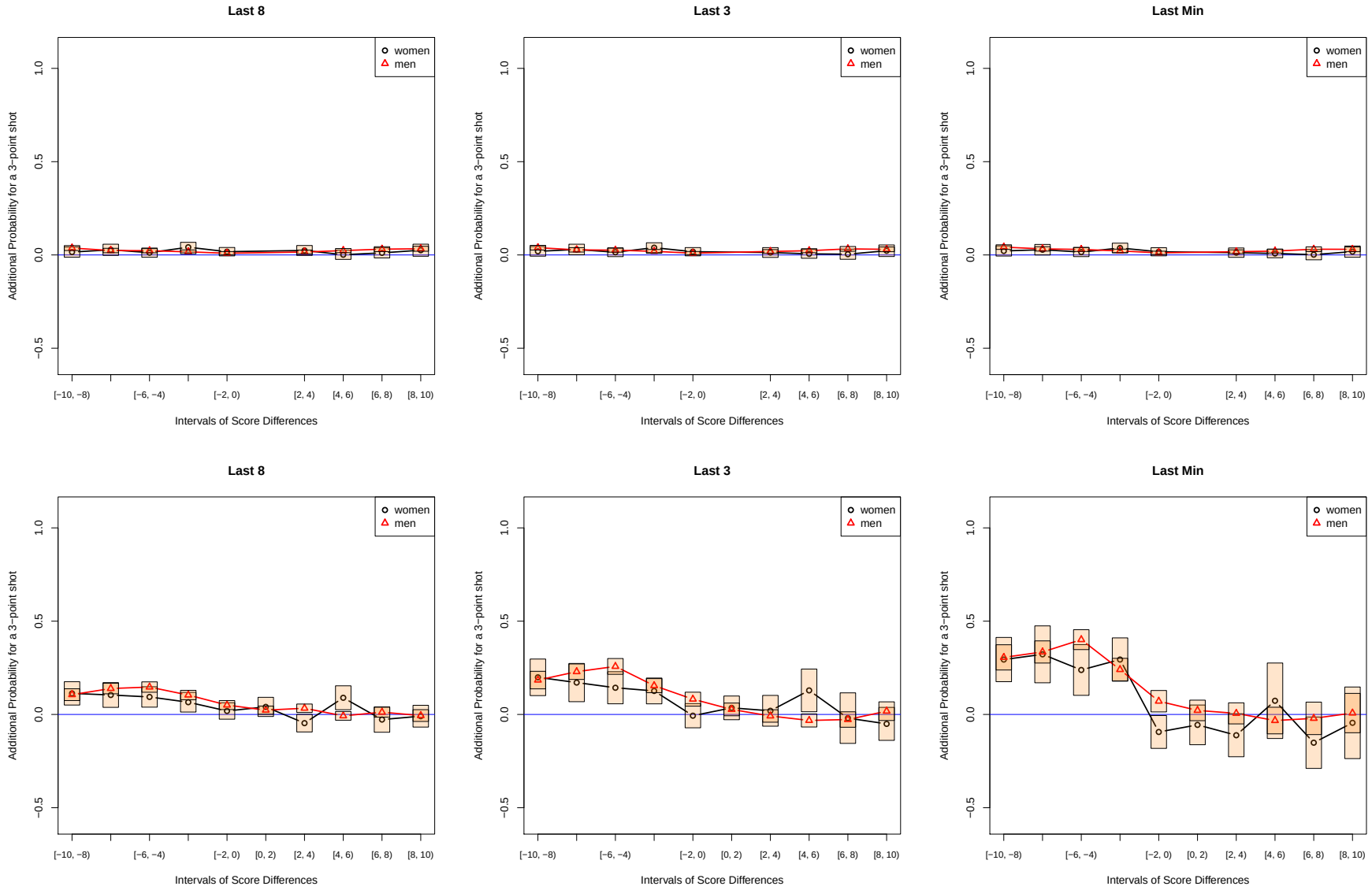
The dataset was generated by downloading match data from websites
http://scores.espn.go.com/wnba/scoreboard for the WNBA and
http://scores.espn.go.com/nba/scoreboard for the NBA. Both websites provide detailed information of the match history at a score attempt level for each match since 2002 including pre-season matches. Thus, for each match every score attempt is available including whether the attempt was successful, the person who made this attempt, and when the attempt was made during the course of the match. The available data from 2002 onwards was downloaded.

In the subsequent preprocessing steps, we dropped all observations from the NBA season 2013/2014 and the WNBA seasons 2013 and 2014. We excluded NBA season 2013/2014 as it had not been completed when the dataset was created. The removal of the last two WNBA seasons 2013 and 2014 was necessary in order to exclude a confounding effect of the change in the three point distance from season 2013 onwards.

In the final dataset, we restrict the analysis to WNBA and NBA playoff matches. The final playoff dataset consists of $177,024$ rows, i.e. shot attempts. $26,033$ rows represent shot attempts from 203 WNBA playoff matches while the remaining $150,991$ rows stem from 970 NBA matches.

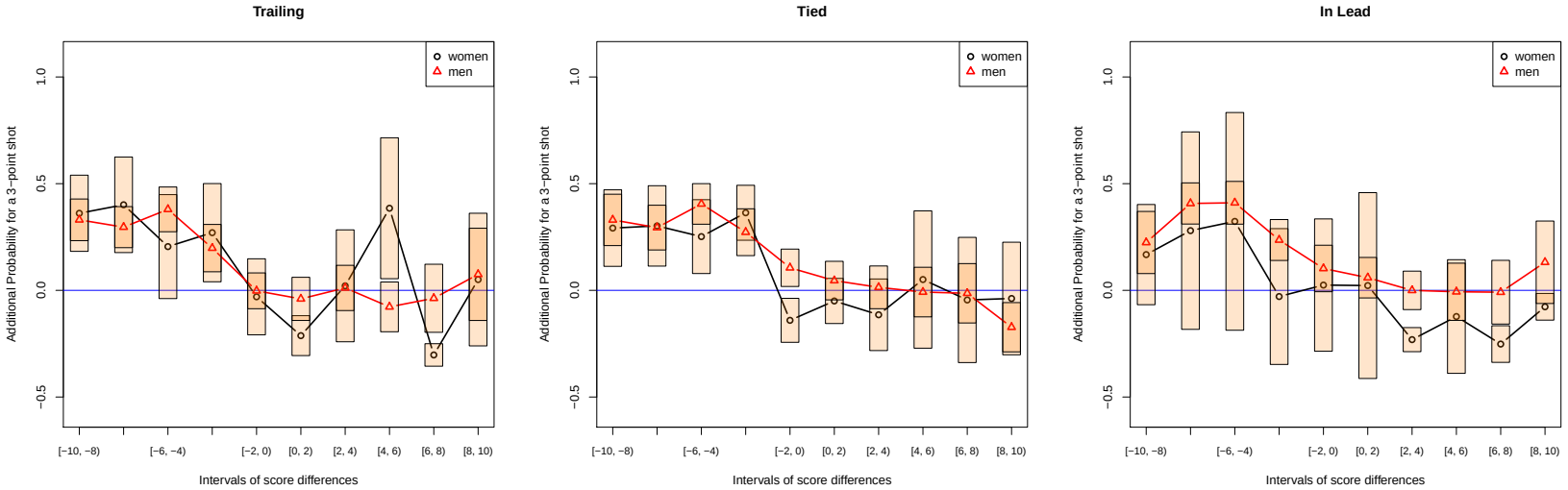
7 Additional Material

Figure 6: Additional probability for a three-point shot during final moments of a match: final 8, 3, and final minutes.



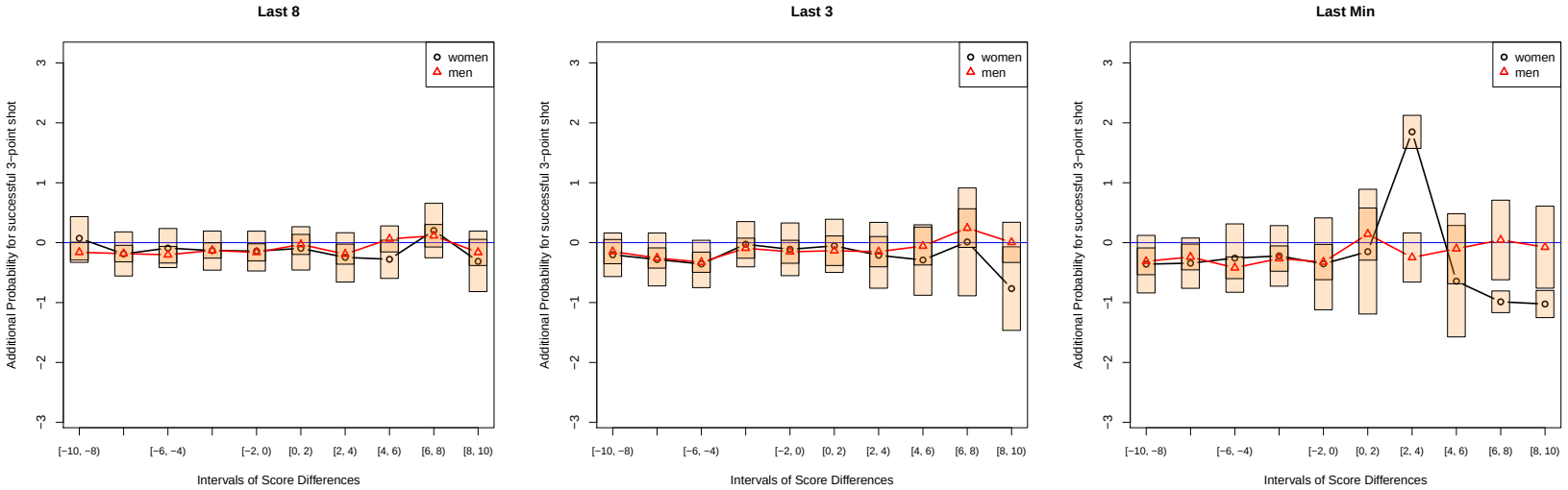
Additional probability for a three-point shot during final moments of a match. Coefficients and standard errors for score difference dummies (top panel) and interaction of score difference dummies and ψ (lower panel). Score difference [0 1) is the omitted base category.

Figure 7: Estimated probability for a three-point shot for the last minute in a match, by trailing, tied or leading in playoff series.



Notes: Estimated probability for a three-point attempt during final moments of a match. Score difference [0 1) is the omitted base category. Playoff standings are grouped as *trailing* (0:1;0:2;0:3;1:2;1:3;2:3), *tied* (0:0;1:1;2:2, and 3:3) and *leading* (1:0;2:0;2:1;3:0;3:1;3:2).

Figure 8: General score difference effect and additional probability for a successful 3-point shot during final moments of a match: last 8, 3 and last minute



Additional probability for a **successful** three-point shot during final moments of a match. Coefficients and standard errors for interaction of score difference dummies and ψ. Score difference [0 1) is the omitted base category.

Table 7: Absolute number of three-point attempts during the match and final minutes

	> last 8		**last 8**		**last 3**		**last min**	
	NBA	WNBA	NBA	WNBA	NBA	WNBA	NBA	WNBA
[-60 -20)	2226	316	1590	214	669	86	226	26
[-20 -10)	11481	2185	3273	799	1308	336	494	127
[-10 -8)	5023	952	1136	281	543	113	247	55
[-8 -6)	6657	1131	1291	274	607	127	277	59
[-6 -4)	8229	1598	1387	333	627	141	291	55
[-4 -2)	10307	1676	1538	380	718	183	305	71
[-2 0)	12249	2075	1553	361	638	173	245	78
[0 2)	13636	2392	1690	369	628	150	214	54
[2 4)	10607	1897	1436	302	588	113	196	22
[4 6)	8137	1491	1222	271	474	77	123	20
[6 8)	6631	1177	1042	215	359	60	84	11
[8 10)	5083	943	921	212	303	56	62	14
[10 20)	11229	2146	3015	677	1086	223	344	68
[20 60)	2104	317	1534	243	601	96	178	21

Notes: Absolute number of observed throwing attempts by time interval during WNBA and NBA matches used in empirical analysis of section 4. Last 8, 3 or 1 minutes is either observed in fourth quarter of any overtime period.

Table 8: Effect of score difference in pressure situations - stratified by playoff series standing: last minute.

	Attempt was when team in playoff series was					
	trailing		**tied**		**in lead**	
Score:	**WNBA**	**NBA**	**WNBA**	**NBA**	**WNBA**	**NBA**
[-60 -20)	-0.103	0.122*	-0.018	-0.048	0.008	-0.014
	(0.16)	(0.063)	(0.194)	(0.043)	(0.158)	(0.054)
[-20 -10)	0.156*	0.140***	0.165**	0.122***	0.265***	0.094**
	(0.082)	(0.027)	(0.066)	(0.036)	(0.099)	(0.043)
[-10 -8)	0.361***	0.330***	0.292***	0.33***	0.168	0.224***
	(0.091)	(0.05)	(0.092)	(0.061)	(0.12)	(0.074)
[-8 -6)	0.401***	0.296***	0.302***	0.294***	0.28	0.407***
	(0.114)	(0.049)	(0.096)	(0.054)	(0.236)	(0.049)
[-6 -4)	0.205*	0.38***	0.252***	0.405***	0.323	0.41***
	(0.124)	(0.054)	(0.088)	(0.048)	(0.26)	(0.051)
[-4 -2)	0.27**	0.198***	0.364***	0.272***	-0.029	0.236***
	(0.091)	(0.043)	(0.053)	(0.045)	(0.158)	(0.056)
[-2 0)	-0.03	-0.002	-0.14***	0.106**	0.025	0.102*
	(0.091)	(0.043)	(0.053)	(0.045)	(0.158)	(0.056)
[0 2)	-0.212***	-0.04	-0.05	0.046	0.022	0.059
	(0.048)	(0.052)	(0.054)	(0.046)	(0.222)	(0.048)
[2 4)	0.021	0.011	-0.114	0.014	-0.231***	0.000
	(0.134)	(0.054)	(0.086)	(0.051)	(0.029)	(0.046)
[4 6)	0.385**	-0.078	0.051	-0.008	-0.123	-0.007
	(0.168)	(0.06)	(0.164)	(0.059)	(0.136)	(0.068)
[6 8)	-0.303***	-0.037	-0.045	-0.014	-0.252***	-0.009
	(0.027)	(0.081)	(0.15)	(0.071)	(0.044)	(0.076)
[8 10)	0.05	0.075	-0.038	-0.173***	-0.077**	0.132
	(0.159)	(0.11)	(0.135)	(0.059)	(0.032)	(0.099)
[10 20)	-0.069	0.135***	0.080	0.076*	0.100	0.104**
	(0.092)	(0.049)	(0.075)	(0.044)	(0.132)	(0.042)
[20 60)	-0.163	-0.077	0.220	0.004	0.14***	0.143**
	(0.217)	(0.06)	(0.176)	(0.058)	(0.024)	(0.071)
N	5262	43954	14763	48808	5202	43465

Note: The dependent variable is equal to 1 if the attempt is a three-point attempt and 0 if it is a two-point attempt. Score indicates the score difference from the attempting team's perspective. Coefficients for time indicators and additional control variables are not reported. All specifications include an indicator for home matches, the number of remaining wins (defeats) to win (lose) the playoff series, the three-point and two-point success rates up to the attempt, and team–play-off round–season fixed-effects. *, **, and *** indicate statistical significance at the 10 percent, 5 percent, and 1 percent level. Clustered standard errors (clustered for team–play-off round–season) in parentheses.