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Risk Taking Behavior in Tournaments: Evidence from the NBA

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ABSTRACT

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We empirically explore the relevance of risk taking behavior in tournaments. We make use of data from the NBA season 2007/2008 and measure risk taking by the fraction of three-point shots. Current heterogeneity of teams is taken into account by intermediate results. It turns out that indeed teams who are behind increase the risk in terms of more three-point attempts. We additionally analyze the consequences of this change in behavior. Enhanced risk taking is inefficient for the vast majority of cases and only beneficial in terms of a higher winning probability if a team is behind with a rather large amount of points. We discuss possible explanations for these decision errors.

JEL Classification: M5

Keywords: basketball, NBA, risk taking, tournaments

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Risk Taking Behavior in Tournaments – Evidence from the NBA

1. Introduction

Performance of individuals or teams is assessed in relation to peer performance in many situations. The better employee will be promoted, the more successful salesperson will receive a bonus, the best R&D team will get an aspired patent or the better sports team in a final will win the championship. These situations are analyzed theoretically as rank-order tournaments in tournament theory. In their seminal contribution *Lazear/Rosen* (1981) explore incentive and selection effects of tournaments. Subsequent papers extent the analysis to heterogeneity of agents (*O'Keeffe/Viscusi/Zeckhauser* (1984)), sabotage as a counterproductive kind of effort (*Lazear* (1989), *Harbring/Irlenbusch* (2008)), or the role of emotions in tournaments (*Kräkel* (2008a)), for instance.

In rank-order tournament type of situations individuals may not only choose an effort level but also affect the outcome by adopting a certain risk strategy. A portfolio manager can take more or less risky assets into account, a sales person may concentrate on traditional or new products or a general manager can invest in traditional or innovative markets, for instance. Theoretical contributions on risk taking behavior in tournaments show that for the case of heterogeneity, less able agents choose riskier strategies (*Bronars* (1987), *Hvide* (2002), *Kräkel/Sliwka* (2004), *Nieken/Sliwka* (2009)). Hereby, heterogeneity usually is defined by differences in effort costs or ability. In practice some information during the tournament can reveal heterogeneity: Portfolio managers realize that their portfolio performs rather weak or a sports team is lying behind during a match, for example. Then agents can react by adjusting their risk strategy.

A typical underlying assumption in the theoretical economic literature is that people fully rationally anticipate the expected outcome of their behavior and adjust their risk strategy in order to maximize individual utility. However, it is hardly established whether decision errors with respect to the risk taking behavior occur in practice. It may well be the case that either

people rather stick to their initial risk strategy in spite of new information so that some kind of status quo bias (*Samuelson/Zeckhauser* (1988)) occurs, or change their strategy considerably due to a rather meaningless information in the sense of a base rate fallacy (*Kahneman/Tversky* (1973)).

We examine both the incidence and the consequences of risk taking behavior in tournaments in this empirical study. We use data from the NBA and analyze teams' tactical orientation. We argue that the fraction of three-point shot attempts acts as a measure for the chosen risk. By observing this risk measure for different periods of games, we mainly refer to the following research questions:

1.) Do teams respond to intermediate scores by adjusting the risk strategy?

2.) Do teams benefit from an increased risk?

Referring to the second question, we also examine certain situations, in which an increase is rather beneficial. Using data from basketball games we have many observations in a rather controlled setting.[1] We indeed find evidence for an increased risk taking of teams lying behind. It turns out that for basketball games an increased risk taking is counterproductive in the vast majority of situations.

Risk taking behavior may not only be fostered by tournaments, but also by other incentive structures that focus on rewarding very good results and that avoid to penalize very bad results. Stock options for managers can be quoted as a well known and broadly discussed example (e.g. *DeFusco/Johnson/Zorn* (1990), *Rajgopal/Shevlin* (2002), *Coles/Naveen/Naveen* (2006)). Besides employed managers usually face limited liability and do not have to personally bear extensive losses (e.g. *Gollier/Koehl/Rochet* (1997)). Our results are therefore interesting and relevant for comparable incentive structures in general.

This is not the first empirical study on risk taking behavior in tournaments, but empirical evidence is rare in particular for the second research question. *Brown/Harlow/Starks* (1996) as well as *Chevalier/Ellison* (1997) and *Taylor* (2003) show for the case of mutual fond managers that not only the expected outcome but also its variance may be affected, when agents choose a certain strategy. E.g., portfolio managers with relative performance contracts, who realize that their own intermediate performance is weak, usually switch to riskier

[1] In some theoretical papers the interaction of effort and risk choice is analyzed (*Kräkel* (2008b)). In this study we assume the effort level as exogenous and concentrate on risk taking behavior.

portfolios. However, *Kempf/Ruenzi/Thiele* (2009) show that this effect may turn around, if managers are afraid of job loss.

A few empirical studies analyze sports and gaming data. *Lee* (2004) examines poker tournaments and confirms that the incentive for risk taking is strengthened by a larger expected gain and bottom-ranked players take more risk. *Genakos/Pagliero* (2009) analyze the risk taking in weightlifting competitions measured by the chosen weight at the decisive attempt and find an inverted-U relationship between risk taking and rank. Both studies do not examine the consequences of risk taking with respect to individual success. Stock car races are examined by *Becker/Huselid* (1992) and *Bothner/Kang/Stuart* (2007). Results include that drivers (as a group) take more risk if both prizes and prize spreads are large or individual drivers take the more risk in a race the higher the number of competitors capable of surpassing them in the series' overall standings. Since risk is measured by observing its consequence, namely accidents in a race, the benefits of risk taking cannot be separated from its incidence in these studies. Additionally, sabotage intentions may be an integral part of risk taking in car racing tournaments, if a driver negligently kicks out a certain opponent. Then it is hard to disentangle the pure risk taking from a sabotage effect.

The paper with the focus closest to ours is a study by *Grund/Gürtler* (2005) who use data of the German soccer Bundesliga. They argue that team managers may change the risk strategy by substitutions of players (e.g. a striker is exchanged for a defender) reacting to a certain intermediate result.[2] They find that managers of trailing teams tend to substitute defenders for midfielders or strikers. This risk taking is counterproductive on average in terms of the probability to enhance the result in the residual time. It cannot be observed, however, whether defenders or even goal keepers rather act as strikers at the end of a game so that the risk measure is somewhat crude since actual behavior is not explicitly observed. They do not take certain time slots of substitutions into account, either.

The paper proceeds as follows: In section 2 we will explore the kind of risk taking behavior in the NBA in more detail and derive our hypotheses. The data and variables are presented in section 3, followed by the results in section 4. Section 5 concludes.

[2] *Garicano/Palacios-Huerta* (2005) also focus on substitutions next to fouls in soccer games, but interpret substitutions of forwards by a defender rather to sabotage than to risk taking.

2. Risk taking behavior in the NBA

As a whole, the NBA League is a one year tournament. 30 teams compete during the regular season and subsequent playoff games for the championship. Also, every single match between two teams can be characterized as a tournament. The team with the higher score wins the game. A draw like in other sports is not possible so that the winner may also be established after a possibly necessary overtime. Since the ranking of a team in the regular season depends solely on the number of wins, the amount of the difference in points does not matter for the winning team. The teams with the highest ranking succeed to the playoffs. Each playoff round of two facing teams is organized as a best-of-seven tournament so that a team with four wins succeeds. Speaking of a tournament in this contribution, we are thinking of a single match with one winning and one losing team.

A game lasts 48 minutes and is divided into four quarters. The time for the offensive team till an attempt is limited to 24 seconds. Therefore, there are many situations, in which players have to make decisions how to try to get points. Coaches explicitly or implicitly affect these decisions by establishing a strategy before the match, during time-outs or by instructions throughout the match. Considering the intermediate score, they may change the tactical orientation of the team during a game.

There are two possibilities to score with regard to the number of possible points in general: First, they can try to shoot from a distance less than 7.24 meters (23’9’’) to get two points if they are successful. Second, they can try to hit the basket from a larger distance (three-point field goal area) in order to get three points if being successful. In both cases an additional point can be received, if the player is fouled at his successful shot and hit a following free shot. Additionally, players have the chance to hit two respectively three free-shots in the case to be fouled and the shot fails.

In the overall 2007/2008 season players hit 0.457 (0.362) of two (three) point shots and three of four free shots (0.755). Fouls of the defending team occur much more often at two-point shots (0.119) than at three-point attempts (0.007). In spite of a foul, more than one quarter of attempts is successful for both two-point and three-point shots. These numbers result in the following distribution of points at two-point, respectively three-point, shots (see Table 1).

Table 1: Distribution, means, and standard deviation of points at two-point and three-point shots

Points	Two-point-shots	Three-point shots
0	0.462	0.633
1	0.032	0.001
2	0.481	0.002
3	0.025	0.362
4	---	0.002
Mean	1.069	1.099
Standard deviation	1.019	1.446
Note: Numbers for the NBA 2007/2008 season. Source: www.nba.com		

The standard deviation of points at a three-point shot is much higher than at a two-point shot, indicating a considerably higher amount of risk (the variance is twice as high). The comparison of the means indicates a slight advantage of three-point shots (1.10) over two-point attempts (1.07). However, an additional benefit from two point shots occurs in a higher probability of fouls, which harms the individual player (who will be disqualified after six personal fouls) and the team as a whole (due to free shots after every foul from the fifth foul of the team in a quarter onwards). We can therefore argue that the expected outcome of two- and three-point attempts is rather comparable, whereas both strategies considerably differ in the variance. In this sense, we speak of an increased (decreased) risk taking behavior, when teams increase (decrease) the fraction of three-point shots during a game. This risk measure has the advantage to others, such as accidents in car races, that we do not have a possible issue of sabotage, but can solely concentrate on risk taking.

We therefore use the fraction of three-point attempts (in percentage points) during a certain period of time as a measure of risk taking behavior. *Bronars* (1987) points out that the leader in a tournament prefers a low risk strategy to assert his position whereas an opponent lying behind has incentives to choose a riskier strategy as this may increase the likelihood that he wins. *Hvide* (2002) as well as *Nieken/Sliwka* (2009) derive the same theoretical result that less able agents (with a lower winning probability) choose riskier strategies. Heterogeneity in sports is revealed by intermediate scores during a certain match. We define the point difference by the points of the regarded team less the opponent's points. We want to examine whether this increased risk taking behavior is relevant in the NBA and formulate

Hypothesis 1:

The risk taking strategy of a team decreases in the point difference during a basketball game in terms of the fraction of three-point shots.

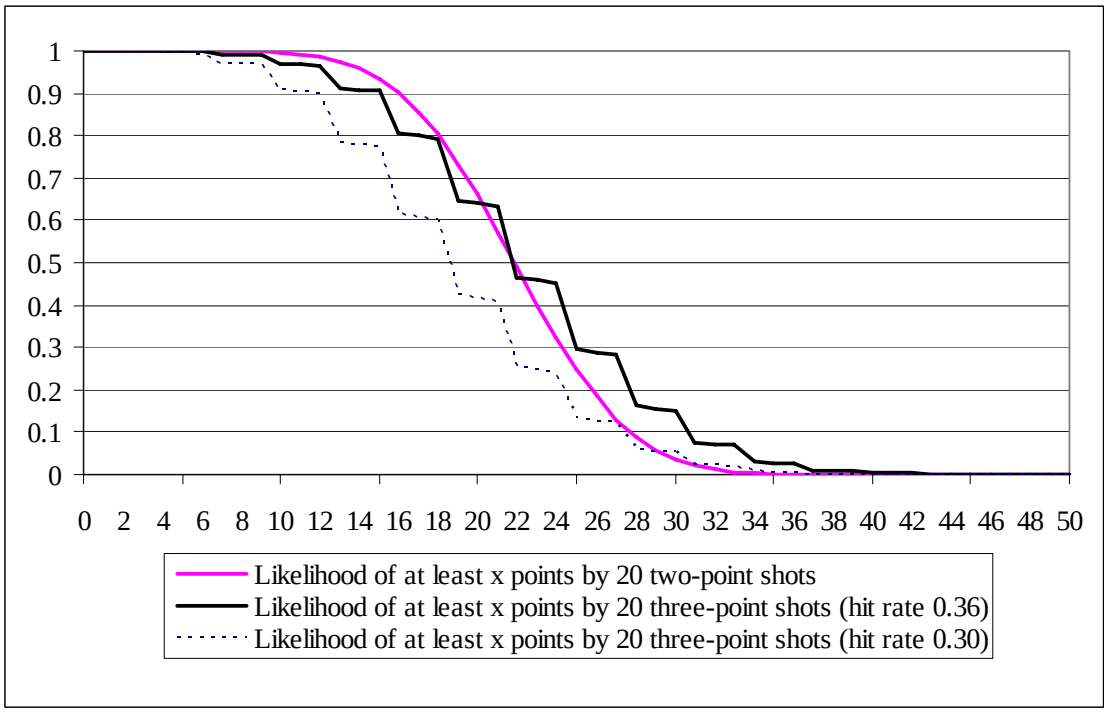
Increasing the risk changes the random distribution of results in the way that probability mass is shifted from the mean to the tails. Hence, extreme results become more likely. Since the higher likelihood of a poor value is not harmful, because damage is limited to losing the game, the increasing probability for a high result makes it more likely for the trailing team to win the game after all. This consideration leads to

Hypothesis 2:

A change to a riskier strategy is beneficial for a team lying behind in terms of an increased chance to win a game.

However, we have to consider that the hit rate for thee-point-shots may be influenced by the risk strategy. Increasing the fraction of three-point shots may implicate attempts in situations, in which is not appropriate to do so. A declining hit rate shifts the distribution function to the left and diminishes the likelihood that the three-point strategy is advantageous. Figure 1 exemplifies the two opposing effects: The two continuous curves show the distribution function to receive at least a number of points attempting 20 two-point shots respectively three-point shots using the hit rates of the NBA as described in Table 1. E.g., the probability to receive at least 27 points is more than twice as high for three-point attempts (0.28) than for two-point attempts (0.13). However, this advantage decreases, if the hit rate of three-point shots drops due to a change of the risk strategy (for example from 0.36 to 0.30, see the dotted curve). In our example, the point for which the advantageous in terms of the likelihood of a high result changes, increases from 23 to 30.

Figure 1: Distribution function to receive at least a number of points with 20 two-point and three-point attempts respectively



Therefore, a risky strategy may especially help, when a team is lying behind with a considerable number of points. We rephrase this statement as our

Hypothesis 3:

Increasing the risk is more beneficial in terms of a higher winning probability the smaller (more negative) the absolute point difference is.

3. Data and Variables

We make use of the games of the NBA season 2007/2008.[3] Each of the 30 teams plays 82 games during the regular season. Additionally we use information on 86 playoff games, which results in a sample size of 2,632 observations from 1,316 games. The data was collected from the officially website of the NBA (www.nba.com), where information on every single attempt during every game is provided.

[3] Due to the availability of comprehensive data, the NBA case has already been used in previous studies on different topics such as escalation of commitment effects and sunk costs (*Staw/Hoang* (1995), *Camerer/Weber* (1999)) or compensation and discrimination (*Bodvarsson/Brastow* (1998), *Hoang/Rascher* (1999)).

We also examine subsamples of games. It may well be the case that incentives to win are destroyed for some teams or at some point of time during the game. First, teams without any chance to reach the playoffs may have even an incentive to lose in order to benefit from an earlier pick in the upcoming draft system (*Taylor/Trogdon* (2002)). We therefore also consider the subgroup of teams who have qualified for the playoffs in the 2007/2008 season ensuring to observe only teams that really benefit from winning. Second, it is obvious that the playoff games are particularly important for teams so that we also analyze this sub-sample. Last, but not least, the intermediate score of each game is public at any point of time. This is different to other tournaments in firms, when employees compete for a promotion, for example. This information may destroy incentives since the trailing team may realize that the point difference at some point of time is too large to have any chance to catch up. In this case it is quite common in the NBA that the team lying hopelessly behind substitutes their best players, followed by the same strategy of the opponent. This leads to a somewhat different game, which is hardly comparable to the serious game before. We therefore also examine the subgroup of games without give-ups at certain points of time. We take four points of time into account and exclude observations for the subgroup, in which a team is lying behind with 1.) at least 24 points after the third quarter, 2.) at least 21 points 9 minutes before the end, 3.) 17 points six minutes before the end, and 4.) 12 points three minutes before the end. There is no team that won the game being behind for more points than these mentioned thresholds. We will also refer to these four points of time with respect to the risk taking behavior in our empirical analysis. The sample size considerably decreases by applying these limitations. For instance, in 40 percent of games the winner is rather established 3 minutes before the end using our defined threshold. Table 2 provides an overview of subgroups' sample sizes.

Table 2: Number of observations

	All	**Give-ups excluded**			
		t=12	**t=9**	**t=6**	**t=3**
All	2,632	2,472	2,334	2,082	1,634
Playoff teams	1,484	1,384	1,312	1,158	904
Playoff games	172	162	154	130	100
Note: t=*x*: No give-up *x* minutes before the end of the game.					

In the subsequent parts of the paper we will refer to the following notation: Points of time are noted in brackets so that [12] means 12 minutes before the end of a game and time is captured from the start of a game [48] to the end [0]. A period of time from m minutes to play until n minutes to play is written as [m-n].

In our empirical investigation, we examine the risk taking behaviour at the end of games and its consequences with respect to the probability of winning a game. We calculate the fraction of three-point attempts during the last 12 (9, 6 and 3) minutes for every team and game (Risk[12-0], Risk[9-0], Risk[6-0], Risk[3-0]). Our hypothesis is that teams lying behind choose a particularly high risk to increase the chance to catch up. We therefore examine, whether the intermediate score explains the risk taking behaviour and expect a negative effect of the point difference (team's score - opponent's score) at a certain point of time on the risk strategy during the minutes left. Hence, we observe the point difference 12, 9, 6 and 3 minutes before the end. We also take into account the risk taking behaviour in the first three quarters (Risk[48-12]) as a benchmark for the previous tactical orientation of a team.

Control variables include information on the relative quality of a team revealed in other games, measured by the difference in won games of a team and its opponent over the whole regular season (Difference in wins), whether a team plays at home or away (Home match) and whether a team also played the day before (Consecutive match day). The latter variable is included in order to capture possible modifications of the tactics due to a somewhat exhausted team. *Nutting* (2009) finds that NBA teams with fewer days since their last game produce fewer wins. We also include team dummies in our analysis.

It is important to note that we have two observations per game (one for each team). We checked that there is hardly any correlation for the absolute risk taking figure and the change of risk taking behavior between teams in a game (see Table A1 in the appendix). All results are robust for the sub-sample of observations of teams lying behind. Table 3 provides an overview of the descriptive statistics of our variables.

Table 3: Descriptive statistics (whole sample)

	N	Mean	Sd	Min	Max
Risk [48-12]	2632	20.83	7.585	1.587	49.09
Risk [12-0]	2632	26.11	12.36	0	70.00
Risk [9-0]	2632	26.89	13.72	0	80.00
Risk [6-0]	2632	27.94	16.92	0	87.50
Risk [3-0]	2631[a]	29.85	23.33	0	100.0
Point difference [12]	2632	0	12.81	-45	45
Point difference [9]	2632	0	13.24	-47	47
Point difference [6]	2632	0	13.64	-48	48
Point difference [3]	2632	0	14.15	-49	49
Home match	2632	0.500	0.500	0	1
Consecutive match day	2632	0.220	0.414	0	1
Difference in wins	2632	0.000	19.20	-51	51

[a] There is one team that did not shoot at all in the last three minutes of one game, so the risk figure can not be determined.

4. Results

As a first result it can be established that both teams increase risk during the fourth quarter. Figure 2 illustrates that teams behind go for more three-point attempts, especially in the last three minutes, while the leading teams increase the risk only slightly. This result is even more apparent, if give-ups are excluded (see Figure A1 in the appendix). The risk increase of the teams being behind is in line with our first hypothesis. However, also the teams being ahead before the last quarter increase the fraction of three-point shots significantly in the last 12 minutes of the game (t-test on two dependent samples; p=0.000 for both teams behind and ahead).[4]

[4] One may speculate that in some situations it is demanding for teams to push the ball near the basket. In this case effort costs may rather increase for two-point attempts when players are exhausted at the end of the game. Therefore, a general increase in three-point shots may occur.

Figure 2: Fraction of three-point shots for different time periods[5]

In our multivariate analysis we will test, whether the increase in risk is more pronounced for teams lying considerably behind, i.e. whether the risk at the end of the game is decreasing in the intermediate point difference. The fraction of three-point shots during the remaining time slots act as dependent variables (see Table 4).

The OLS regression analysis reveals that the intermediate point difference (which is negative for the trailing team) has a significant negative impact on risk taking. The more a team is lying behind, the more three-point attempts are shot. The coefficient is stable for all different points of time examined here. Alternative specifications with several dummy variables of point difference categories confirm the results in general. The negative linear relation turns around for high leads, though. This category, however, includes several observations for that the trailing team has no realistic chance to catch up.

As expected, the risk taking in the first three quarters, as a measure for the initial tactical orientation in the game, is highly significantly positive related to the risk taking behavior in the last minutes of the game. There is no significant effect for all other control variables, such as playing at home, the overall performance difference of teams or playing also the day before. There is no increased risk taking in the last minutes for playoff games in general.

[5] The teams are classified by the score at the beginning of the respective period of time, while for period [48-12] the score after the third quarter is used.

However, there might be a different reaction on point difference in playoff games compared to the whole season. We explore this by looking at the respective subsamples.

Table 4: Determinants of risk-taking

	(1) Risk[12-0]	(2) Risk[9-0]	(3) Risk [6-0]	(4) Risk [3-0]
Home match	-0.256	-0.139	-0.586	-1.717*
	(0.466)	(0.524)	(0.669)	(0.969)
Difference in wins	0.001	-0.006	-0.034	-0.024
	(0.018)	(0.020)	(0.025)	(0.037)
Playoff game	-0.030	-0.257	-0.074	-1.390
	(1.061)	(1.159)	(1.5185)	(2.066)
Consecutive match day	-0.000	-0.025	-0.444	-1.259
	(0.574)	(0.006)	(0.777)	(1.128)
Risk [48-12]	0.271***	0.288***	0.239***	0.135*
	(0.037)	(0.041)	(0.051)	(0.073)
Point difference [12]	-0.064***			
	(0.020)			
Point difference [9]		-0.094***		
		(0.022)		
Point difference [6]			-0.113***	
			(0.028)	
Point difference [3]				-0.100***
				(0.039)
Team dummies	yes	yes	yes	yes
Constant	15.321***	15.410***	16.965***	21.053***
	(1.332)	(1.426)	(1.729)	(2.456)
Observations	2632	2632	2632	2631[a]
R-squared	0.16	0.14	0.10	0.05

Robust standard errors in parentheses

[a] There is one team that did not shoot at all in the last three minutes of one game, so the risk figure can not be determined.

* significant at 10%; ** significant at 5%; *** significant at 1%

Table 5 only shows the results for the point difference coefficients of the same specification as in Table 4 for the considered subsamples. As expected, the influence of the point difference on the three-point shots is pointed out more clearly when give-ups are excluded. Furthermore, the coherence becomes stronger, the fewer minutes are to be played, and the stronger the incentives to win are. So in playoff games with three more minutes to go, each additional point increasing the deficit raises the fraction of three-point attempts by 1.6 percentage points if the game is not yet decided. All the results are highly significant.

Table 5: Effect of Point difference on risk taking for sub-samples

Dependent variable		Risk [12-0]	Risk[9-0]	Risk [6-0]	Risk [3-0]
Independent variable		Point difference [12]	Point difference [9]	Point difference [6]	Point difference [3]
Whole sample	All	-0.064***	-0.094***	-0.113***	-0.100***
	Give-ups excluded	-0.116***	-0.183***	-0.302***	-0.699***
Playoff teams	All	-0.076***	-0.110***	-0.182***	-0.171***
	Give-ups excluded	-0.144***	-0.203***	-0.427***	-0.830***
Playoff matches	All	-0.082	-0.190**	-0.383***	-0.374**
	Give-ups excluded	-0.084	-0.273**	-0.738***	-1.565***

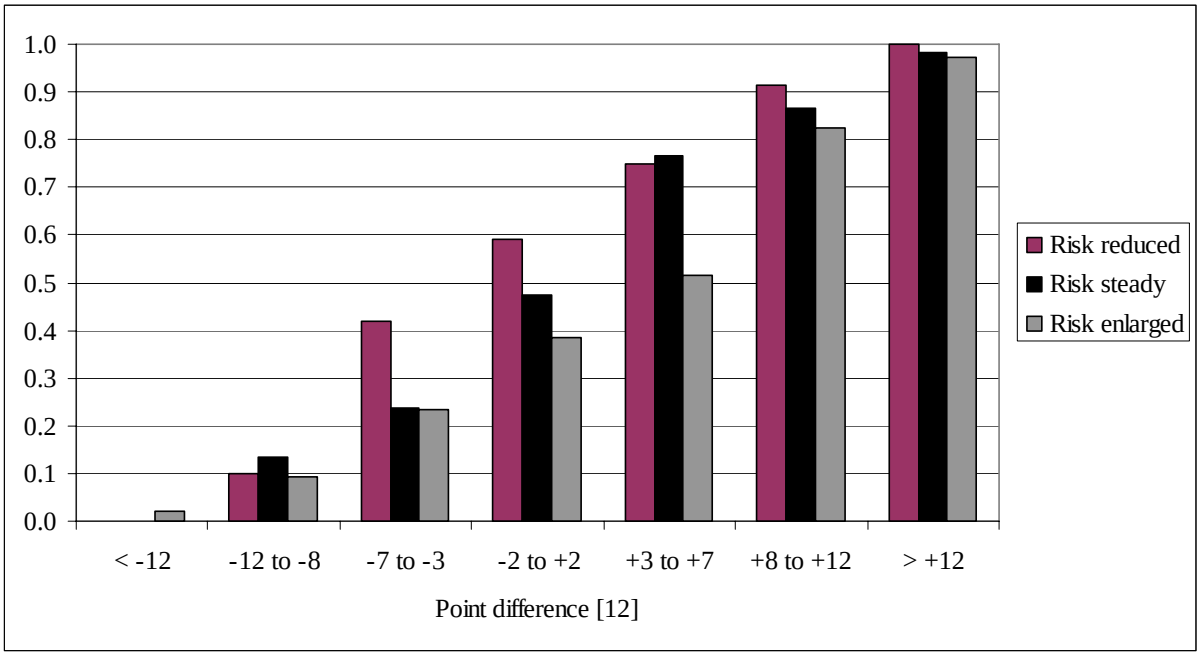
Least square regression with robust standard errors.
* significant at 10%; ** significant at 5%; *** significant at 1%.
Further independent variables accounted for: Home match, Difference in wins, Playoff game, Consecutive match day, Risk[48-12], and team dummies (see Table 4).
The complete output of the 20 regressions is available from the authors by request.

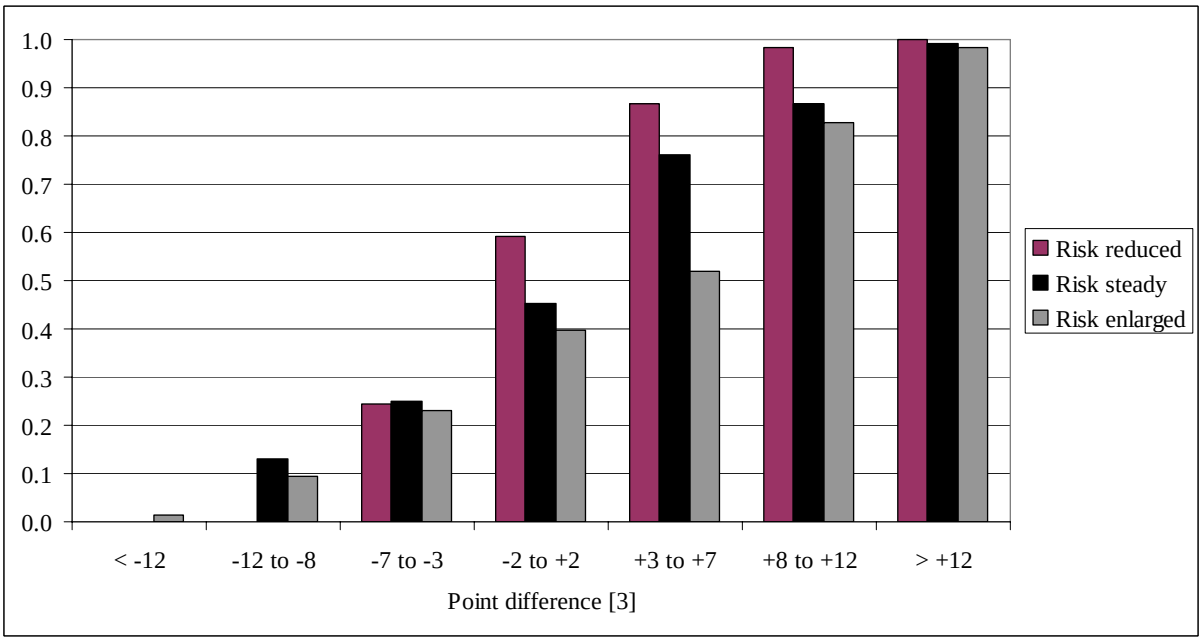
Overall, the findings show clear evidence for the first hypothesis. Teams lying behind react by going for more risk in terms of an increased fraction of three-point attempts.[6]

As formulated in the second hypothesis, we will analyze if this reaction is beneficial. Figure 3 provides a first impression by showing the fraction of winning teams in regular time, subject to the point difference twelve and three minutes before the end of the game, respectively, and contingent on the change in risk taking behavior. The latter is regarded as enlarged (reduced) if the proportion of three-point shots is increased (lowered) by at least 5 percentage points compared to the first three quarters. A variation of less than 5 percentage points is treated as steady. As Figure 3 shows, the enlargement of risk may be just appropriate for very high deficits, since the probability of winning a game is higher for a reduced risk in most other cases. For example, 42 percent of teams trailing by three to seven points after the third quarter and reducing the risk in the fourth quarter still manage to win. This is only the case for 23 percent of corresponding teams that increase the fraction of three-point shots (see Table A2 and Table A3 in the appendix for detailed numbers and Table A4 and Table A5 for an itemization with regard to the opponent's risk taking). However, more than half of teams choose a risk enhancing strategy in this situation, while only one of six teams reduces risk.

[6] Additionally, we conducted a pooled regression of all points of times in all games to ensure that no time effect is skewing the results for the separate regressions. Since we obtained very similar coefficients, we continue with separate analyses for the different points of time.

Figure 3: Fraction of wins subject to change in risk taking behavior and point difference [12] and [3] respectively





The results of a binary logit estimation for winning the game are presented in Table 6. Obviously, and not surprisingly, the point difference has a highly significant and strong impact: the larger the lead, the larger the winning probability, of course. This effect becomes even more pronounced the fewer minutes are left. The change in risk taking (dRisk) is measured as the difference of the fraction of three-point shots in the analyzed time period (last 12, 9, 6 or 3 minutes respectively) and the fraction in the first three quarters. The results

reveal a clearly negative and highly significant influence of a risk enlargement on the winning probability for all analyzed time periods. For example, a raise of the fraction of three-point shots by five percentage points in the last quarter reduces the odds of winning on average by about 14 percent.

Table 6: Determinants of winning a game (binary logit estimates)

	Game won			
	[t=12]	[t=9]	[t=6]	[t=3]
Home match	0.458***	0.295**	0.181	-0.006
	(0.122)	(0.134)	(0.144)	(0.171)
Difference in wins	0.030***	0.029***	0.020***	0.015**
	(0.004)	(0.005)	(0.006)	(0.006)
Consecutive match day	0.058	-0.016	-0.007	-0.001
	(0.145)	(0.158)	(0.170)	(0.197)
Point difference [t]	0.200***	0.253***	0.307***	0.415***
	(0.008)	(0.010)	(0.013)	(0.018)
dRisk[t-0]	-0.029***	-0.023***	-0.025***	-0.016***
	(0.005)	(0.005)	(0.004)	(0.004)
Team dummies	yes	yes	yes	yes
Constant	-0.134	-0.133	-0.123	-0.169
	(0.370)	(0.371)	(0.391)	(0.381)
Observations	2632	2632	2632	2631[a]
R-squared	0.486	0.564	0.626	0.715

Robust standard errors in parentheses
[a] There is one team that did not shot at all in the last three minutes of one game, so the risk figure can not be determined.
* significant at 10%; ** significant at 5%; *** significant at 1%

Furthermore, the difference in wins throughout the whole season has an expected positive and significant impact on the winning probability, while there is no coherence if the team played the day before. The influence of playing at home is positive and significant for the analysis of the last quarter, but becomes smaller the fewer minutes are to go. The results are nearly identical if only teams behind are considered (see Table A6 in the appendix).

Table 7 shows that the results are robust with respect to different subsamples. There is nearly no difference if give-ups are excluded. The negative effect of risk enlarging becomes even stronger for playoff teams or playoff matches, while the impact becomes smaller the less minutes are to go. Again, we obtain similar results for evaluations restricted to trailing teams (see Table A7 in the appendix).

Table 7: Risk taking coefficients for winning the game (sub-samples)

Dependent variable		Game won			
Independent variable		dRisk[12-0]	dRisk[9-0]	dRisk [6-0]	dRisk [3-0]
Whole sample	All	-0.029***	-0.023***	-0.025***	-0.016***
	Give-ups excluded	-0.029***	-0.023***	-0.025***	-0.016***
Playoff teams	All	-0.037***	-0.031***	-0.026***	-0.016***
	Give-ups excluded	-0.037***	-0.031***	-0.026***	-0.016***
Playoff matches	All	-0.076**	-0.058**	-0.026	-0.030
	Give-ups excluded	-0.076**	-0.058**	-0.026	-0.030

Logistic regression for game won with robust standard errors.
* significant at 10%; ** significant at 5%; *** significant at 1%.
Further independent variables accounted for: Home match, Difference in wins, Consecutive match day, team dummies and depending on the analyzed time period Point difference[12], [9], [6] and [3], respectively.

Since the effect of a change in risk taking may depend on the point difference, interaction terms for point difference categories and the change of risk are taken into account. Five categories of point difference are defined by the thresholds shown in Table 8. The extreme thresholds vary for different points of time because a certain point difference is more severe, the fewer minutes are left to play. The values are geared to the critical values for give-ups, namely approximately half of them. The first category “Behind” can be seen as a severe deficit, the second as a slight handicap with still good chances left. The third category stands for a nearly balanced score. In category four the team is a bit ahead, while in category five it has very good chances to win.

Table 8: Thresholds for point difference categories

Point of time	Point difference category				
	(1) Behind	(2) Slightly behind	(3) Even	(4) Slightly ahead	(5) Ahead
[12]	< - 12	-12 to -3	-2 to +2	+3 to +12	> +12
[9]	< - 10	-10 to -3	-2 to +2	+3 to +10	> +10
[6]	< - 8	-8 to -3	-2 to +2	+3 to +8	> +8
[3]	< - 6	-6 to -3	-2 to +2	+3 to +6	> +6

Table 9 shows the results of the respective logistic regressions, including the interaction effects of the change in risk taking and the categories of intermediate scores. The category *even* acts as the reference. First, it can be seen that the categories for point difference have the expected and significant impact on winning probability. The main effects of increasing the

risk are very similar to the results in the regression without interaction terms. For moderate point differences there are no significant interaction effects. Only if a team lies clearly behind, an increased risk taking in the last 12 minutes (and with limited extent in the last 9 minutes) raises the winning probability, since the aggregated effect is significantly positive. This corresponds to the few cases of higher likelihoods of winning for teams lying considerably behind and increase risk shown in Figure 3. Increasing the risk jeopardizes the good chances to win for teams being ahead. Except for the case a team clearly leads and three minutes to go, the interaction effects become weaker the fewer minutes are to be played. All qualitative effects remain stable for sensible other thresholds. Focussing on the subsample without give-ups does not affect the results.

Table 9: Determinants of success – with interaction terms

	(1) [t=12]	(2) [t=9]	(3) [t=6]	(4) [t=3]
Home match	0.516***	0.326**	0.187	-0.008
	(0.117)	(0.129)	(0.143)	(0.169)
Difference in wins	0.032***	0.030***	0.021***	0.019***
	(0.004)	(0.005)	(0.005)	(0.005)
Consecutive match day	0.051	0.002	-0.055	-0.045
	(0.140)	(0.151)	(0.164)	(0.192)
Behind [t]	-5.507***	-4.382***	-4.597***	-4.512***
	(0.796)	(0.460)	(0.515)	(0.435)
Slightly behind [t]	-1.082***	-1.374***	-1.446***	-1.894***
	(0.158)	(0.184)	(0.203)	(0.276)
Slightly ahead [t]	1.250***	1.263***	1.362***	1.637***
	(0.157)	(0.169)	(0.178)	(0.203)
Ahead [t]	5.087***	4.405***	4.377***	4.339***
	(0.641)	(0.420)	(0.383)	(0.327)
dRisk[t-0]	-0.026***	-0.021**	-0.031***	-0.023***
	(0.009)	(0.008)	(0.007)	(0.006)
Behind [t] * dRisk [t-0]	0.100***	0.037**	0.020	-0.001
	(0.031)	(0.016)	(0.033)	(0.020)
Slightly behind [t] * dRisk [t-0]	-0.005	-0.006	-0.005	0.001
	(0.012)	(0.013)	(0.012)	(0.014)
Slightly ahead [t] * dRisk [t-0]	-0.010	0.000	0.020**	0.010
	(0.012)	(0.012)	(0.010)	(0.009)
Ahead [t] * dRisk [t-0]	-0.052*	-0.030	0.001	0.032***
	(0.027)	(0.018)	(0.014)	(0.012)
Team dummies	yes	yes	yes	yes
Constant	-0.232	-0.093	-0.037	0.041
	(0.360)	(0.377)	(0.415)	(0.393)
Observations	2632	2632	2632	2631[a]
R-squared	0.471	0.543	0.619	0.700

Logistic regression for game won with robust standard errors in parentheses

[a] There is one team that did not shoot at all in the last three minutes of one game, so the risk figure can not be determined.

* significant at 10%; ** significant at 5%; *** significant at 1%

To sum up, our results show that risk enlarging is not beneficial in most cases. So hypothesis 2 has to be rejected. Hypothesis 3 is supported in the regressions for 12 and 9 minutes to go in terms of a positive interaction effect between point difference categories and changes in risk taking.

This rises the question why teams react by enlarging the risk, although this strategy is usually not appropriate. A possible explanation may be that the teams systematically overestimate the benefit of increasing the fraction of three-point shots in the sense of the base-rate fallacy. They may give too much weight to the new information (point difference) and too little to the basic information that resulted in the originally chosen risk strategy. It may well be the case that some public pressure from spectators, or the owner of the clubs, leads to a change in risk strategy. If a deficit becomes obvious, retaining the strategy might be interpreted as ignoring the situation and not trying everything to catch up in the remaining time. Anticipating this, coaches may even take more risk in order to signal a kind of pro-active behavior when being aware of a decreasing winning probability.

5. Conclusion

The strategy of individuals or teams with respect to risk taking is highly relevant in many tournament kind of situations, when subjects are assessed in relation to each other. Making use of basketball data, we show that protagonists indeed adjust their risk strategy based on new information concerning the intermediate score in a game. Trailing teams increase the fraction of three-point shots in the last minutes of a game. Surprisingly, this reaction is not beneficial in terms of an increasing winning probability in most cases.

Therefore, teams lying behind take too much risk too early in a game. This decision error may firstly be interpreted as irrational behavior of the coaches in charge of the strategy. Coaches may underestimate decreasing hit rates at increased risks. This may partly be explained by choking under pressure, which is defined as performance decrements under circumstances that increase the importance of good or improved performance (*Baumeister* (1984)). Players may become aware of the importance of an improved performance especially when coaches announce changes in strategy. *Baumeister/Steinhilber* (1984) show for several cases that this pressure can be relevant for the home teams in particular. However, we do not find indications in our data that home teams increase risks to a greater extent or that they are particularly affected by the following failures. Second, the hasty increased risk taking may be interpreted as a reaction to some incentives of signalling pro-active behavior due to public

pressure as mentioned above.[7] If this second argument is relevant, this is contrary to career concerns or herding behavior of managers, who have incentives to stick to their initial strategy and abstain from innovative, not well established, investment decisions due to certain incentives (see *Kanodia/Bushman/Dickhaut* (1989), *Scharfstein/Stein* (1990)).

Whether individuals take risks rather cautiously or distinctively, obviously depends on incentives for achieving very good or avoiding very bad results. A team lying behind in a basketball game only benefits from a very good result in the remaining time that is sufficient for catching up and winning the game. Stock option plans or limited liability of managers induce similar effects. In contrast, managers may rather want to ensure their own jobs by avoiding very bad results. This is in line with experimental evidence by *Gaba/Kalra* (1999), who find that risk taking behavior in tournaments is decreasing in the number of winners for a given number of participants.

The three-point rule has been introduced by the NBA in the season 1979/1980 to make the game more interesting, and indeed we find that for the case of a team lying considerably behind the three-point shot strategy is an appropriate tool to catch up, although this strategy is used too early in many cases. Implementing an appropriate incentive system for risk taking is a huge challenge for a principal, and the systems are supposed to differ considerably between portfolio managers and R&D teams, for instance. Based on our results, club owners (who are aware of the decision errors) may adopt incentives for coaches and/or players by introducing a fine for defeats with many points, for instance.[8]

A possible correlation of the outcomes of risky strategy across opponents has to be taken into account for a number of cases. *Nieken/Sliwka* (2009) show theoretically and experimentally that for the case of a high correlation, it may be beneficial for a leading agent to simulate the opponent's (risky) strategy. This effect is likely to be relevant for portfolio managers, for instance. However, a considerable correlation of the result of three-point shots is not likely in basketball games.

Future research may compare risk taking behavior and its consequences in different incentive structures systematically.

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[7] If this is true, the effect is similar to the phenomenon that coaches in professional team sports are dismissed quite often (due to public pressure), even though the benefits of such a proceeding are not evidenced (see *Wirl/Sagmeister* (2008)).

[8] *Gilpatric* (2009) shows theoretically that some sanctions for worst performance can inhibit pronounced risk taking.

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Appendix

Table A1: Correlation between risk-taking of the observed team and the opponent in different time periods

	Correlation coefficient (p-value)
dRisk [12-0]	-0.029 (0.131)
dRisk [9-0]	-0.013 (0.507)
dRisk [6-0]	-0.018 (0.368)
dRisk [3-0]	-0.009 (0.651)
dRisk [12-9]	-0.027 (0.167)
dRisk [9-6]	-0.006 (0.756)
dRisk [6-3]	-0.011 (0.558)
Note: Change of Risk [x-y] = Risk [48-12] - Risk [x-y]	

Figure A1: Fraction of three-point shots for different time periods with give-ups excluded (n=2632, 2471, 2333, 2082, and 1633 respectively)

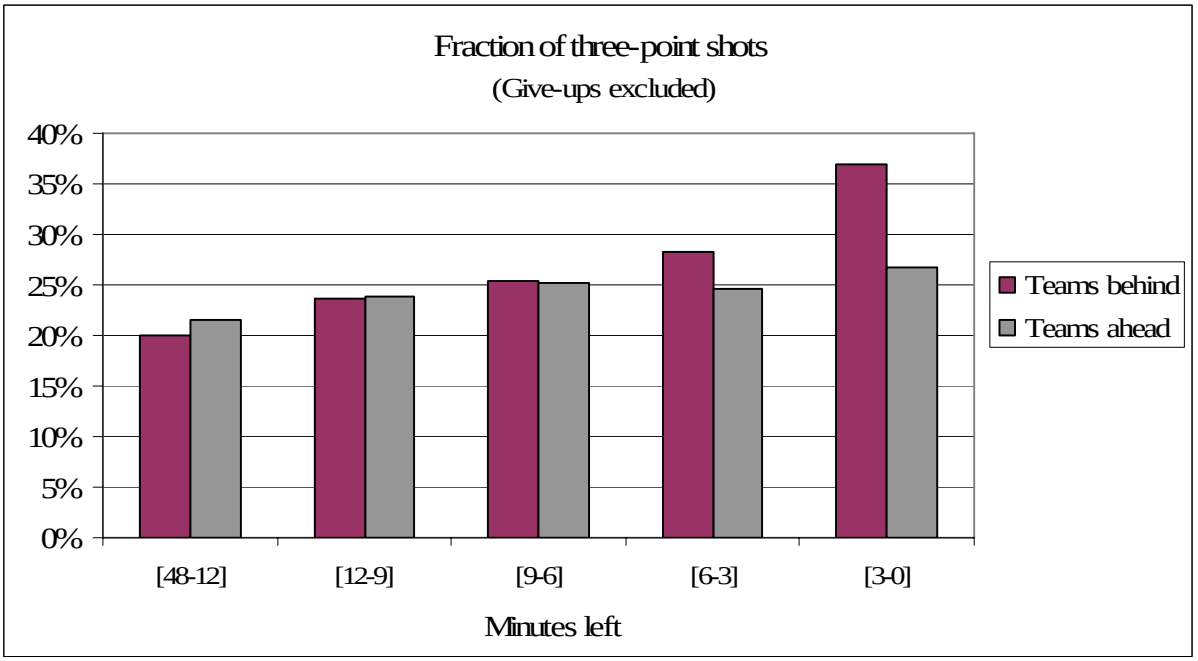

Table A2: Portion of winning teams subject to point difference [12] and risk taking behavior

	Point difference [12]						
	< -12	**-12 to -8**	**-7 to -3**	**-2 to +2**	**+3 to +7**	**+8 to +12**	**> +12**
Game won	**0**	**31**	**103**	**188**	**250**	**259**	**420**
Portion (won | risk ↘)	0.00	0.10	0.42	0.59	0.75	0.91	1.00
Portion (won | risk ⇨)	0.00	0.13	0.24	0.48	0.77	0.87	0.98
Portion (won | risk ↗)	0.02	0.09	0.23	0.38	0.51	0.82	0.97
Total	**420**	**301**	**386**	**418**	**386**	**301**	**420**
Portion (risk ↘)	0.19	0.17	0.16	0.19	0.22	0.23	0.29
Portion (risk ⇨)	0.31	0.22	0.28	0.29	0.33	0.30	0.29
Portion (risk ↗)	0.49	0.60	0.54	0.51	0.45	0.43	0.40

Table A3: Portion of winning teams subject to point difference [3] and risk taking behavior

	Point difference [3]						
	< -12	**-12 to -8**	**-7 to -3**	**-2 to +2**	**+3 to +7**	**+8 to +12**	**> +12**
Game won	**0**	**1**	**32**	**160**	**284**	**280**	**493**
Portion (won | risk ↘)	0.00	0.00	0.25	0.59	0.87	0.98	1.00
Portion (won | risk ⇨)	0.00	0.13	0.25	0.45	0.76	0.87	0.99
Portion (won | risk ↗)	0.01	0.09	0.23	0.40	0.52	0.83	0.98
Total	**493**	**283**	**351**	**378**	**351**	**283**	**493**
Portion (risk ↘)	0.35	0.18	0.15	0.29	0.34	0.40	0.40
Portion (risk ⇨)	0.26	0.24	0.32	0.30	0.36	0.35	0.26
Portion (risk ↗)	0.43	0.64	0.60	0.59	0.50	0.47	0.35

Table A4: Proportion of winning teams subject to point difference [12], the observed team's change in risk taking and opponent's change in risk taking

Point difference [12]	Risk taking	Risk taking of opponent		
		Risk ↘	**Risk ⇨**	**Risk ↗**
-12 to -8	Number of wins		**31**	
	Risk ↘	0.00	0.00	0.25
	Risk ⇨	0.00	0.13	0.18
	Risk ↗	0.07	0.11	0.10
-7 to -3	Number of wins		**103**	
	Risk ↘	0.50	0.35	0.41
	Risk ⇨	0.12	0.14	0.40
	Risk ↗	0.11	0.19	0.32
-2 to +2	Number of wins		**188**	
	Risk ↘	0.44	0.52	0.68
	Risk ⇨	0.43	0.43	0.47
	Risk ↗	0.20	0.45	0.44
+3 to +7	Number of wins		**250**	
	Risk ↘	0.46	0.84	0.78
	Risk ⇨	0.65	0.76	0.79
	Risk ↗	0.52	0.50	0.53
+8 to +12	Number of wins		**259**	
	Risk ↘	0.91	0.92	0.91
	Risk ⇨	0.89	0.87	0.86
	Risk ↗	0.70	0.79	0.88

Table A5: Proportion of winning teams subject to point difference [3], the observed team's change in risk taking and opponent's change in risk taking

Point difference [3]	Risk taking	Risk taking of opponent		
		Risk ↘	**Risk ⇨**	**Risk ↗**
-12 to -8	Number of wins		**1**	
	Risk ↘	0.00	0.00	0.00
	Risk ⇨	0.00	0.00	0.00
	Risk ↗	0.00	0.03	0.00
-7 to -3	Number of wins		**32**	
	Risk ↘	0.11	0.50	0.24
	Risk ⇨	0.17	0.17	0.10
	Risk ↗	0.00	0.06	0.09
-2 to +2	Number of wins		**160**	
	Risk ↘	0.38	0.60	0.67
	Risk ⇨	0.30	0.50	0.45
	Risk ↗	0.18	0.39	0.42
+3 to +7	Number of wins		**284**	
	Risk ↘	0.72	0.75	0.91
	Risk ⇨	0.50	0.83	0.81
	Risk ↗	0.56	0.75	0.84
+8 to +12	Number of wins		**280**	
	Risk ↘	0.95	1.00	0.99
	Risk ⇨	1.00	1.00	0.97
	Risk ↗	1.00	1.00	1.00

Table A6: Determinants of success (for teams behind only)

	Game won			
	[t=12]	[t=9]	[t=6]	[t=3]
Home match	0.300	0.029	0.030	0.094
	(0.189)	(0.214)	(0.230)	(0.289)
Difference in wins	0.030***	0.028***	0.031***	0.020*
	(0.007)	(0.008)	(0.009)	(0.011)
Consecutive match day	0.083	-0.019	0.060	0.043
	(0.221)	(0.240)	(0.264)	(0.322)
Point difference [t]	0.216***	0.307***	0.347***	0.491***
	(0.021)	(0.029)	(0.036)	(0.058)
dRisk[t-0]	-0.023***	-0.024***	-0.030***	-0.021***
	(0.007)	(0.007)	(0.007)	(0.008)
Team dummies	yes	yes	yes	yes
Constant	0.397	0.291	0.053	-14.89***
	(0.520)	(0.559)	(0.663)	(0.496)
Observations	1274	1280	1278	1249
R-squared	0.252	0.320	0.315	0.390

Note: Robust standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

Table A7: Risk taking coefficients for winning the game (teams behind only)

		dRisk[12-0]	dRisk[9-0]	dRisk [6-0]	dRisk [3-0]
Whole sample	All	-0.023***	-0.024***	-0.032***	-0.021***
	Give-ups excluded	-0.023***	-0.024***	-0.030***	-0.021***
Playoff teams	All	-0.027***	-0.032***	-0.026***	-0.020*
	Give-ups excluded	-0.027***	-0.032***	-0.026***	-0.020*
Playoff matches	All	-0.131***	-0.082*	-0.062	[a]
	Give-ups excluded	-0.131***	-0.082*	-0.062	[a]

Logistic regression for Game won with robust standard errors.
Further independent variables accounted for: Home match, Difference in wins, Consecutive match day, team dummies and depending on the analyzed time period Point difference[12], [9], [6] and [3], respectively.
[a] Regression not possible due to the small number of trailing teams who win.