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Abstract

This paper assesses the role of distance in professional team sports, taking the example of football (soccer). We argue that a team's performance in terms of scored and conceded goals decreases with the distance to the foreign playing venue. To test this hypothesis empirically, we investigate 6,389 away games from the German Football Premier League ('Erste Deutsche Bundesliga') between the playing seasons 1986-87 and 2006-07. We find that distance contributes significantly in explaining a guest team's propensity to concede goals, but not so for scoring goals. Focusing on the difference between scored and conceded goals ('goal difference') as a measure of the overall success of a football team, we observe a significant and non-monotonic impact of distance on team performance.

JEL Codes: L25, L83, C29

Keywords: Professional team performance; distance; event count data; poisson regression model

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1 Introduction

The economic literature is full of examples demonstrating that geographical distance affects the behavior of households and firms in a systematic way. The importance of distance has been illustrated, for instance, in labor economics (e.g., commuting behavior of employees; see van Ommeren, Rietveld and Nijkamp 1997, 1999), international economics (e.g., production and location decisions of firms; see Markusen 2002), urban and regional economics (e.g., agglomeration forces in space; see Fujita and Thisse 2002) or public economics (e.g., effect of sales taxes on cross-border consumer behavior; see Kanbur and Keen 1993). When it comes to empirical application, the *gravity model* is one of the leading frameworks to analyze the effects of distance. For example, bilateral trade flows are usually explained by characteristics of home and host country markets (e.g., market thickness, firm competition) along with (bilateral) distance.[1]

To analyze the role of distance on firm behavior the previous research mainly relies on aggregate data (volumes of exports and imports, number of firms in a specific market, number of commuters, etc.). The corresponding findings are only valid for specific industries (if industry data is used) or even for the whole economy. However, it might be more interesting whether firms are differently exposed to distance due to different types of mobility costs or simply due to the existence of economies of scale. Unfortunately, information about output at the firm-level is often ambiguous and hardly available, and even if it exists, distance usually does not vary within the observational units (for example, all German firms exporting to China have the same distance entries). This, in turn, renders an efficient parameter estimation nearly impossible.

In this paper we address this issue by relying on a dataset from professional team sports. Following the recent literature from game theory and industrial organization we argue that a professional sports team might be viewed as a firm (see, e.g., Anderson, Ayton and Schmidt 2008). Analyzing the economic performance of this firm within the 'market' (league) allows to observe an unambiguous output measure. Since the pairs of competing

[1] One typical result in this regard is that bilateral trade is negatively affected by distance, indicating that it is more difficult for a given (exporting) firm to serve a more distant foreign market (see, e.g., Bergstrand 1985, Egger 2000).

teams are changing over each round of a playing season we can also apply a distance variable that varies within the observational units.

To illustrate the role of distance on team performance we focus on the example of professional football (soccer). For this purpose, we employ a dataset from the German Football Premier League (henceforth 'Bundesliga'), including 38 teams and 21 playing seasons between 1986-87 and 2006-07. The output of these 'firms' is scored and conceded goals, which, ultimately, determine the success and the performance of a team at the end of the season. We would expect that teams playing farther away from their home location score fewer and/or concede more goals, all else equal. One reason for the potential decrease in team performance might be that traveling to the foreign playing venue is more cumbersome and/or that the living conditions are less familiar when the foreign location is relatively far away.[2]

Our dataset comprises information at the bilateral level (i.e., home-guest team-pairs), varying over rounds and years. The dependent variables are goals ('counts') scored and conceded within a fixed playing time. Furthermore, we use the difference between scored and conceded goals (henceforth 'goal difference'), which might be viewed as an alternative measure of a football team's success. Since we are interested in the performance of a football team at foreign playing locations we only focus on away games.[3] In our case, the dataset includes 6,389 away games. Empirically, we estimate a gravity model using a count data estimation framework. To control for the offensive and defensive abilities of the home team we include the most recent performance of the opponent (i.e., goals scored and conceded in the previous five rounds), the capacity utilization at the playing venue (match

[2]There is evidence from sports medicine that the immune system of professional football players and, consequently, their sensitivity to physical diseases is systematically affected by the frequency of exhaustive journeys (see Gabriel and Kindermann 1997, Bury, Marechal, Mahieu and Pirnay 1998, Nieman and Pedersen 1999). Further, we directly asked coaches, team and traveling managers, and providers of medical services of some Bundesliga teams about their personal experience regarding the impact of traveling activities on team performance. Most of them share the view that the players' performance in away games is potentially influenced by distance, and that it might be especially worse for long-distance travels. Often used strategies to circumvent this problem are to travel by airplane or to arrive one or two days before the matchday.

[3]There is a considerable research on the home ground advantage in football (see, e.g., Pollard 1986, Clarke and Norman 1995, Nevill, Newell and Gale 1996, Goddard 2005). In some of these papers, distance enters only indirectly by analyzing whether a potential home advantage is vanishing in local derbies. To the best of our knowledge, however, the role of distance on team performance in away games has not been addressed so far.

attendances to stadium capacity) and factors determining the mental and physical capacities of a guest team (i.e., the number of coaches within a season). Further, it might be suspected that distance exerts a non-monotonic impact on team performance. For instance, if the venue of the away game is relatively close to the home location, it might be that teams arrive at the same day, and, therefore, are faced with a relatively exhausting journey (see also footnote 2). This, in turn, makes it conceivable that distance exhibits a strong but diminishing influence on the (offensive and defensive) performance of a team. We take account for such effects by introducing squared distance as an additional regressor.

Our findings suggest that distance exerts a significantly negative and non-monotonic impact on a football team's defensive performance. In other words, the guest team's success to prevent a goal decreases the farther away the playing venue is from the home location. However, the impact of distance is non-monotonic, indicating that the performance of a team becomes worse up to a certain distance. Beyond this 'critical' point (estimated at around 450 kilometers), the team's defensive behavior improves again. Regarding scored goals, we are not able to identify a significant role of distance. Focusing on the difference between scored and conceded goals as a potentially more adequate measure of a football team's overall performance, we observe again a significant negative and non-monotonic impact of distance. These findings are in line with our expectations from above, and, qualitatively, also confirm the empirical evidence from the aforementioned fields of economic interest.

The remainder of the paper is organized as follows. Section 2 presents the data and some descriptive statistics. Section 3 elaborates the econometric specification and discusses the empirical findings. Section 4 concludes.

2 Data and descriptive statistics

2.1 Data description

Our sample used in the empirical analysis below includes 6,389 away games for 38 teams from the Bundesliga between the playing seasons 1986-87 and 2006-07. For this purpose we build up a unique database containing comprehensive information about the performance of the teams and their most important economic characteristics. Information about team performance (number of seasons within the sample period, end of year rank, goals scored and conceded for each round and year) is taken from various web sources (see Appendix A.1 for details). In the empirical analysis, we further use data about stadium capacities, the match attendances per game and the number of head coaches within a season. The corresponding information is collected from the official web page of the German Football Association ('Deutscher Fussball Bund') and other web resources (listed in Appendix A.1). Bilateral (geographical) distance is available from `http://maps.google.at`.

2.2 Descriptive statistics

Table 1 summarizes the main characteristics of the included football teams along with information about distances between the home location and the foreign playing venues. The teams are sorted by their average distance to the other playing venues.[4] The average football team stood in the Bundesliga for ten seasons (see column 1 in Table 1) with a maximum value of 21 seasons (six teams) and a minimum of one season (five clubs).[5] Columns 2 and 3 report each team's best and worst rank at the end of the playing season. Accordingly, there are only five teams that won the championship at least once within the sample period (1.FC Kaiserslautern, Bayern Muenchen, Borussia Dortmund, VfB Stuttgart and Werder Bremen).

Columns 4 and 5 of Table 1 show the offensive and defensive abilities of each team. Accordingly, a guest team scores approximately 1.2 goals, on average. The corresponding value for conceded goals is slightly above 1.7. We observe a negative goal difference for all teams except one (Bayern Muenchen) and only two teams are close to a balanced score (Bayer 04 Leverkusen and Werder Bremen). The maximum goal difference is around -1.9 (FC Homburg), indicating that this team concedes nearly two goals more than it scores in the average away game.

[4]See Appendix A.2 for descriptive statistics of the full sample (Table A1) and the full bilateral distance matrix (Table A2).

[5]The German football league system was formed in 1963. Since then, the structure and organization of the league system has changed frequently. In each season the Bundesliga encompasses 18 teams (the exception is playing season 1991-92 with 20 teams due to the German reunification). Each team plays against every other team once at home and once away, which gives 34 rounds (1991-92: 38 rounds). The three (1991-92: four) teams at the bottom of the end of year ranking are descended into the Second Bundesliga, while the top three (1991-92: two) teams in the Second Bundesliga are promoted.

Table 1: Team performance and distance in the Bundesliga, averages over 1986-2006

Club	No. of seasons (max. 21)	Rank[a]		Goals[b]		Distance[b]	Capacity utilization[c]	Coaches[d]
		Best	Worst	Scored	Conceded			
Blau-Weiß 90 Berlin	1	18	18	0.941	2.647	541.765	0.298	1.000
Hansa Rostock	11	6	18	1.012	1.785	533.673	0.707	1.750
Bayern Muenchen	21	1	10	1.565	1.203	532.759	0.944	1.364
Energie Cottbus	4	13	18	0.785	1.877	527.477	0.744	1.000
TSV 1860 Muenchen	10	4	17	1.188	1.788	524.718	0.757	1.300
Dynamo Dresden	4	13	18	0.725	2.014	523.130	0.508	1.600
SpVgg Unterhaching	2	10	16	0.941	2.088	513.000	0.697	1.000
Hertha BSC Berlin	11	3	18	1.178	1.783	487.984	0.766	1.636
SC Freiburg	10	3	18	1.044	1.950	480.513	0.709	1.000
Hamburger SV	21	2	13	1.227	1.684	453.949	0.695	1.545
FC St. Pauli	6	12	18	0.853	1.862	441.735	0.547	1.333
VfB Leipzig	1	18	18	0.706	2.412	437.059	0.501	3.000
SSV Ulm 1846	1	16	16	0.813	2.313	406.063	0.774	1.000
1.FC Nuernberg	14	5	17	1.030	1.770	405.025	0.589	1.533
Werder Bremen	21	1	13	1.347	1.395	395.591	0.692	1.182
VfB Stuttgart	21	1	15	1.251	1.610	388.714	0.683	1.409
VfL Wolfsburg	10	6	15	1.082	1.835	375.582	0.725	1.500
1.FC Kaiserslautern	19	1	16	1.210	1.761	357.706	0.659	1.400
1.FC Saarbruecken	1	18	18	1.063	2.375	356.500	0.475	1.000
Stuttgarter Kickers	2	17	17	1.457	2.314	354.829	0.350	1.000
Alemannia Aachen	1	17	17	1.059	1.941	347.765	0.847	2.000
Karlsruher SC	11	6	16	1.090	1.778	343.450	0.526	1.083
FC Homburg	3	11	18	0.608	2.471	337.333	0.299	2.667
1.FSV Mainz 05	3	11	16	1.020	1.700	329.820	0.835	1.000
Hannover 96	7	10	18	1.034	1.674	327.563	0.676	1.714
Arminia Bielefeld	7	12	18	0.966	1.790	308.900	0.731	1.429
Borussia M'Gladbach	19	3	18	1.111	1.867	301.783	0.738	1.800
Schalke 04	18	2	18	1.102	1.618	296.378	0.794	1.579
MSV Duisburg	8	8	19	0.992	1.855	292.790	0.658	1.778
Eintracht Frankfurt	16	3	17	1.074	1.730	291.380	0.638	1.824
Bayer 04 Leverkusen	21	2	15	1.413	1.446	285.079	0.633	1.409
Borussia Dortmund	21	1	13	1.327	1.507	284.490	0.781	1.091
VfL Bochum 1848	16	5	18	1.147	1.929	278.574	0.594	1.235
SV Waldhof Mannheim	4	12	17	0.838	2.000	277.059	0.328	1.250
1.FC Koeln	16	2	18	1.165	1.698	276.213	0.688	2.000
Bayer 05 Uerdingen	8	8	18	0.919	1.778	275.281	0.429	1.625
Wattenscheid 09	4	11	17	1.116	2.217	259.348	0.457	1.200
Fortuna Duesseldorf	6	9	20	0.885	1.990	252.163	0.516	2.285
Average	*10*	–	–	*1.158*	*1.713*	*368.328*	*0.678*	*1.219*

Notes: [a] Rank at the end of the playing season. [b] Average over all away games and playing seasons. [c] Match attendances to stadium capacity, average over all away games and playing seasons. [d] Number of coaches per season (average over all playing seasons).

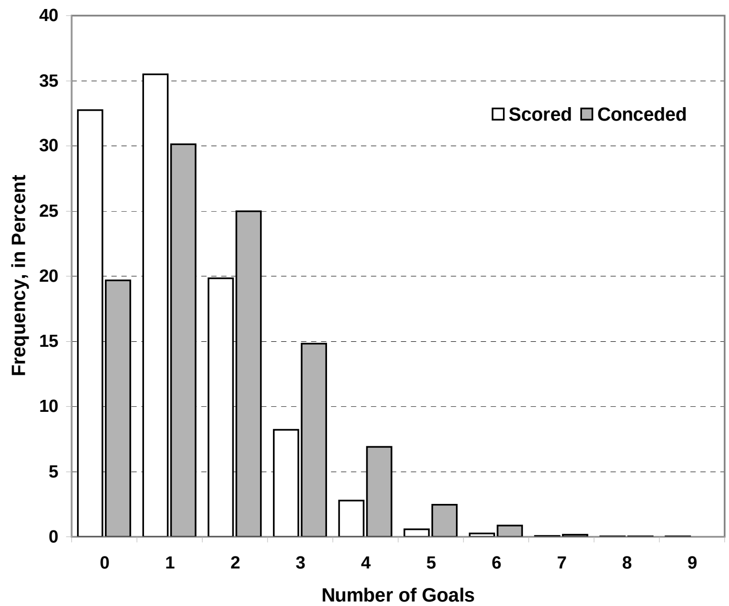

Figure 1: Distribution of scored and conceded goals (away games)

Further details on the distribution of scored and conceded goals are depicted in Figure 1. Two features of the data deserve special attention. Firstly, for most of the away games we observe zero or one goals (in about 70 percent of all games; the share of zeroes is about 33 percent). This is not the case for conceded goals, where we mainly observe one or two goals (about 55 percent) and a relatively low share of zeroes (about 20 percent). Secondly, for scored goals we have a much lower variation than for conceded ones (in the sample the corresponding standard deviations are 1.13 and 1.36, respectively; see Table A1 in the Appendix).

Information about the average geographical distance of a team to the other playing venues is reported in column 6 of Table 1. The average distance to other locations is around 368 kilometers, lying within a range of 542 kilometers (Blau-Weiß 90 Berlin) and 252 kilometers (Fortuna Duesseldorf).[6] The question of interest in our context is whether team performance is systematically affected by the geographical distance to the foreign playing venue? However, Table 1 does not allow to answer this question definitely.

[6]As can be seen from Table A2 in the Appendix, the maximum bilateral distance is 805 kilometers (Hansa Rostock against Karlsruher SC and SC Freiburg against Hertha BSC Berlin).

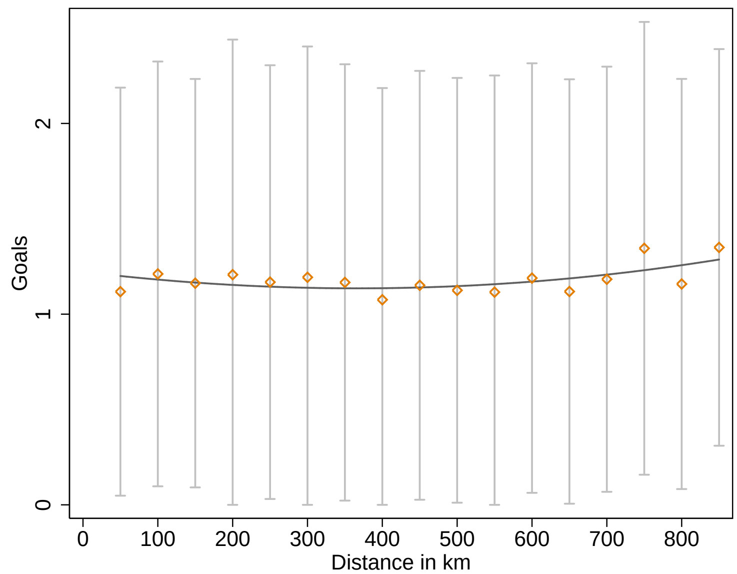

Figure 2: Distance and scored goals (away games)

For instance, if we use the clubs' best end of season rank as a performance measure within the group of relatively distant teams, we can find ones that are highly successful (e.g., Bayern Muenchen or Hamburger SV) and others that are quite ineffective (e.g., Dynamo Dresden or Energie Cottbus). Similarly, focusing on the averages of scored and conceded goals and taking the group of teams that are relatively close to each other, we can observe, for example, teams with a high amount of scored goals, and others with a relatively low score. Examples for the former (latter) ones are Bayer 04 Leverkusen and Borussia Dortmund (SV Waldhof Mannheim and Fortuna Duesseldorf).

To gain additional insights into the relationship between team performance and distance we provide Figures 2 to 4. Specifically, we draw (i) scored goals (Figure 2), (ii) conceded goals (Figure 3), and (iii) the goal difference (Figure 4) against distance, where the whole sample is clustered into 50 kilometer cohorts. The entries in the figures indicate mean values of goals (scored, conceded and goal difference) for each distance cohort, and the whiskers illustrate the corresponding standard deviations.

The graphical inspection of the figures tends to support the following conclusions. Firstly, a comparison between Figures 2 and 3 confirms the empirical picture from above that there are fewer goals scored than con-

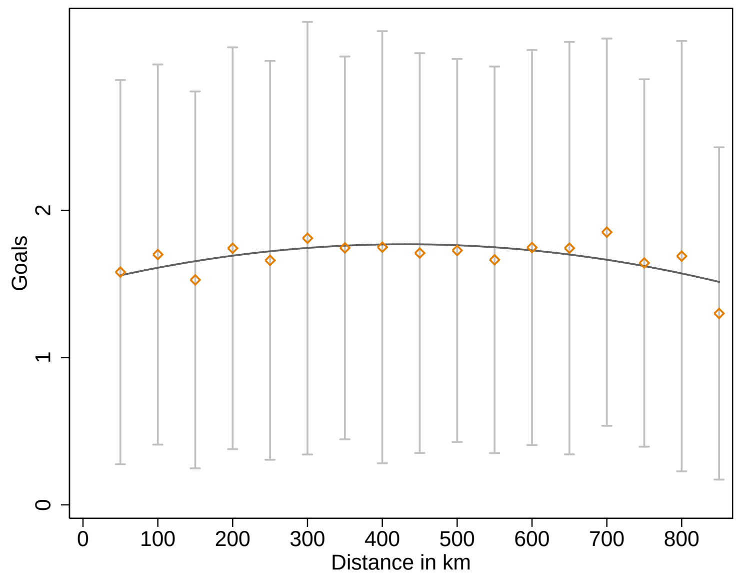

Figure 3: Distance and conceded goals (away games)

ceded, irrespective of whether a team is close or relatively distant to other playing venues. This is also in line with Figure 4, illustrating that the goal difference is negative throughout. There is only one entry near zero for very distant locations (above 800 kilometers), indicating a probably outlying observation (according to Table A2 in the Appendix, there are only few bilateral team-pairs lying within this distance cohort). Secondly, goals scored (conceded) seem to be negatively (positively) related to distance, as expected (by and large, this pattern seems to hold also for standard deviations). In a similar vein, the goal difference becomes worse for more distant locations. Additionally, we observe a non-monotonic impact of distance on team performance (as indicated by the fitted lines through the mean value entries). While there is a u-shaped pattern for goals scored and the goal difference, we obtain a hump-shaped relationship between distance and goals conceded. This motivates the inclusion of a quadratic distance term in our empirical model.

Finally, columns 7 and 8 of Table 1 inform about the capacity utilization and the number of coaches per season. Both variables are included as controls in the empirical analysis below. Thereby, capacity utilization measures the pressure that a guest team is faced with when playing in a foreign venue. Accordingly, the capacity utilization of an average away game is around 68

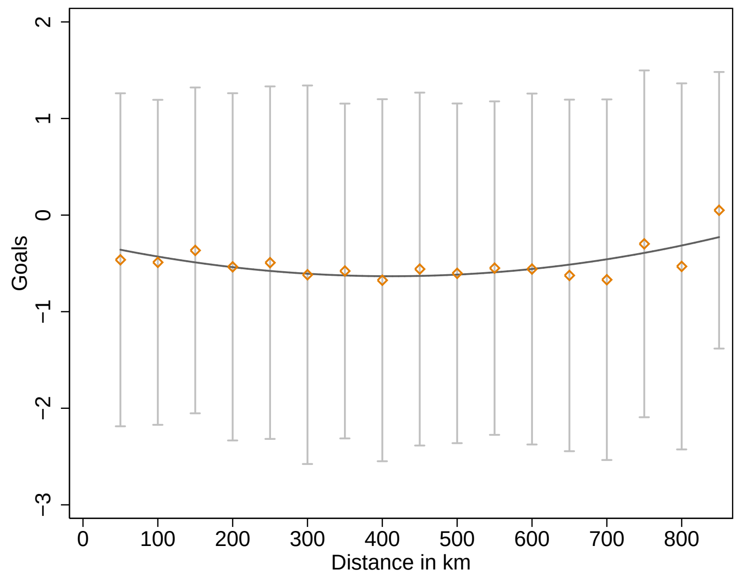

Figure 4: Distance and goal difference (away games)

percent. Again, we observe a large variation for this variable, ranging from a minimum of about 30 percent (Blau-Weiß 90 Berlin and FC Homburg) up to a maximum of approximately 94 percent (Bayern Muenchen). Similarly, for the number of coaches per season we observe a considerable variation over the covered teams. An entry of one in Table 1 indicates that the team never fired its coach during a season. Apart from teams that stood in the Bundesliga for only one or two seasons, there is only one team with a Bundesliga history of more than five years and no changes of the team's coach during the playing season (SC Freiburg). Close to this are teams like Borussia Dortmund and Karlsruher SC with values around 1.1. At the other extreme, teams like VfB Leipzig, FC Homburg and Fortuna Duesseldorf fired their head coach more than twice a season, on average.

3 Empirical Analysis

3.1 Specification and Estimation

To estimate the impact of distance on team performance we regress (i) scored and (ii) conceded goals as well as the (iii) the goal difference in away games on distance and other control variables. By their very nature, these variables are event counts, i.e., number of goals within a fixed playing time. Therefore, we apply a count data framework (see Long 1997, Cameron and Trivedi 1998, Winkelmann 2003). The standard approach to analyze count processes is the *Poisson regression model*,[7] which assumes that the occurrence y_i of an event is drawn from a Poisson distribution with parameter λ (scale parameter)

$$\text{Prob}(Y = y_i|\lambda) = \frac{e^{-\lambda}\lambda^{y_i}}{y_i!}, \quad \lambda \in \mathbb{R}^+, y_i = 0, 1, 2, \ldots, N \tag{1}$$

where Y is a non-negative (outcome) random variable (i.e., scored and conceded goals and the difference between those variables).[8] Note that the Poisson distribution is equidispersed, i.e., $\text{E}(Y) = \text{Var}(Y) = \lambda$.[9]

The Poisson regression model is derived from (1) by parameterizing the relationship between the scale parameter and the explanatory variables. The most common way to parameterize λ is the exponential mean formulation (see Cameron and Trivedi 2005), which, in our case, is given by

$$\lambda_{ij,rs} = \text{E}(y_{ij,rs}|\mathbf{X}) = \exp(\mathbf{X}\boldsymbol{\beta}), \tag{2}$$

where i denotes the i^{th} guest team, j is the j^{th} home team (then ij is a bilateral relationship, i.e., one specific away game) and r stands for a specific round in playing season s. $\mathbf{X}$ indicates a matrix of guest team ($\mathbf{x}_i$),

[7]The Poisson distribution is also a widely accepted device to investigate the distribution of the number of goals in sports involving two competing teams (see Maher 1982, Lee 1997, Baxter and Stevenson 1988, Rue and Salvesen 2000).

[8]The goal difference is negative in about 50 percent of all away games. However, the Poisson regression model is only applicable for non-negative integer values, and, therefore, we add the absolute amount of the worst goal difference (i.e., the minimum value of -7; see Table A1 in the Appendix) to each observation, so that the whole distribution of the goal difference variable is shifted to the right. Transforming the goal difference variable in this way enables us to provide unbiased and consistent estimation results.

[9]For this reason the Poisson model is often viewed as too restrictive (see Cameron and Trivedi 1998, Winkelmann 2003). A natural way to proceed is to estimate a negative binomial model, which relaxes the equidispersion assumption. The negative binomial model further allows to test for equidispersion (see Cameron and Trivedi 1998, pp. 77). Applying the negative binomial model, we obtain almost the same parameter estimates as for the Poisson model. Further, testing for equidispersion we are not able to reject this assumption (see Karlis and Ntzoufras 2000, for a similiar result from the Greek Football League). Finally, Figures A1 and A2 in the Appendix clearly demonstrate that the observed count outcomes for scored and conceded goals are close to the predicted Poisson distributions with identical means. Only for the (transformed) goal difference we obtain some systematic deviations, especially for zero and one goals (see Figure A3). For these reasons and for the sake of brevity, we only report the estimates of the Poisson model below. Results for the negative binomial model are available from the authors upon request.

home team ($\mathbf{x}_j$) and team-pair specific ($\mathbf{x}_{ij}$) vectors of covariates (including the constant). The coefficient vector $\boldsymbol{\beta}$ is estimated via (quasi) maximum likelihood. Since $\lambda = \mathrm{E}(y_{ij,rs}|\mathbf{X}) = \mathrm{Var}(y_{ij,rs}|\mathbf{X}) = \exp(\mathbf{X}\boldsymbol{\beta})$, the error term of the Poisson regression is inherently heteroskedastic. We take account for this by estimating White (1980) robust standard errors (see Cameron and Trivedi 1998).

Regarding the explanatory variables, we firstly include our main variable of interest, i.e., distance, which is the only team-pair specific covariate in our empirical model. From the discussion above we suspect that distance exerts a non-monotonic impact on team performance (see also Figures 2 to 4). Therefore, we incorporate squared distance in addition to the simple (linear) distance term. Following the presumption that performance is negatively related to distance, we expect a negative impact of distance on scored goals and the goal difference and a positive effect on conceded goals. For squared distance we predict the opposite sign as for the simple distance term.

The remaining explanatory variables are guest and home team specific. Firstly, we include the number coaches of the guest team within a season until the matchday. This variable might capture the mental abilities of a team, and, to some extent, also the physical constitution of the players (e.g., via different training methods). Further, the coach is responsible for the playing strategy in a game. Following previous research, we would argue that the performance of a team decreases with the number of coach changes, especially for teams with an excessive hiring and firing strategy (see, e.g., Audas, Dobson and Goddard 2002, Koning 2003).

Secondly, the ratio of match attendances to total stadium capacity at the playing venue controls for the pressure that a guest team is faced with when playing in a foreign venue (see, Nevill et al. 1996, for a related analysis of the effects of match attendances on home team advantage). Here, we would expect that team performance is affected via two distinct channels. On the one hand, a higher capacity utilization increases the mental stress of the players and the team, leading to fewer scored and more conceded goals and, therefore, to a more negative goal difference. On the other hand, the capacity utilization might be anticipated by a more defensive behavior of the guest team. If such a strategy is successful, we would expect a lower score of conceded goals. Moreover, a team with a special focus on the defense tends to score less goals. Taking these aspects together, the overall impact of capacity utilization on team performance remains ambiguous.

Thirdly, we account for the offensive and defensive capabilities of the home team, which is measured by the sum of scored and conceded goals of the opponent in the past five rounds before the considered game (see, Carmichael, Thomas and Ward 2000, for a similiar approach).[10] Accordingly, a high number of scored goals in the past five rounds indicates strong offensive skills of the opponent, while a high score of conceded goals points to a weak defensive performance of the home team. Since the opponent's abilities are thought to capture only within season variation, we set these variables at zero in the first round of a season. If the guest team is playing against an opponent with a strong offense it is more likely that it concedes more goals, all else equal. The effect of a home team's offensive strength on the guest team's offensive performance, however, is less clear. On the one hand, opponents with strong offensive abilities tend to be more vulnerable to counter attacks, leading to more scored goals for the guest team. On the other hand, an opponent with a strong offense might be anticipated by the guest team via a more defensive strategy, which is usually accompanied by a lower number of scored goals. Similarly, we predict a negative impact of the opponent's defensive abilities on scored goals (i.e., the guest team scores more goals if the defense of the home team is weak), while the effect on the guest team's defensive performance is ambiguous. If the home team's priority is on scoring goals rather than on avoiding conceded ones, we would expect that the guest team concedes more goals, on average. Otherwise, we cannot infer a clear relationship between the home team's defensive abilities and the guest team's defensive performance.

Given our data at hand (bilateral relationships for each round and playing season), we use two alternative versions of (2): In *Model A* we include fixed effects for guest teams, home teams and seasons. Guest and home team specific effects capture unobserved components of a team that are not changing over time (e.g., the management style, strategic orientation, long-term financial resources). The fixed season effects encompass common effects that

[10] Our estimation results are rather insensitive to changes of this variable. For instance, using the opponent's performance in the last three rounds rather than in the last five rounds leaves our parameter estimates virtually unchanged.

all teams are exposed to in a specific season (e.g., changes in player payment schemes or transfer controls like the Bosman case).

Model B additionally incorporates interaction terms between guest team and season effects as well as home team and season effects. It further takes round specific effects into account. Including the interactions between guest team (home team) and season effects we allow for a team specific time trend. For instance, it might be argued that some teams are less interested in short-term success, but have a long-term strategy in mind (e.g., to win the championship within a five or ten year horizon). Others are only interested in avoiding a relegation from the Bundesliga. In any case, such effects are mainly embodied by the interaction terms. The fixed round effects capture common effects within a specific round (e.g., it is often claimed that the physical and mental abilities of teams are changing over the course of a season). Overall, we estimate 94 dummy variables in Model A and 774 ones in Model B. Obviously, Model A is a nested version of Model B. Notice that our Poisson regression model as formulated in Models A and B comes close to a standard gravity equation (as used, for example, in the trade literature), where bilateral variables (such as distance) and characteristics of home and host markets along with a bunch of (home and host) country and time fixed effects are included in the regressions.

3.2 Empirical Results

Table 2 summarizes our empirical findings regarding scored and conceded goals as well as the goal difference. For each dependent variable, we provide results for Models A and B as discussed above. As can be seen from Table 2, our empirical model seems well specified. The R^2-measures reported in the lower block of the table are relatively high,[11] and the fixed effects are highly significant in almost all specifications.

Most of the control variables enter significantly and take on the expected sign, especially for the parsimonious models (Model A). Taking conceded goals, for instance, we observe significantly positive parameter estimates for the number of coaches and the opponent's ability to score goals, indicating that a guest team's performance in terms of conceded goals is negatively

[11] See Cameron and Windmeijer (1996) for a comprehensive discussion of various R^2 measures for count data models.

influenced by these variables. Similarly, the guest team is more likely to be successful in scoring goals if the opponent has relatively weak defensive abilities (see Model A for scored goals). Consequently, we find that the goal difference is negatively (positively) related to the opponent's offensive (defensive) abilities. Regarding match attendances to capacity we obtain insignificant parameter estimates throughout. One reason for this finding might be that the two effects discussed above (i.e., mental pressure and anticipatory behavior) outweigh each other.

For Model B, we generally observe a less clear picture about the explanatory variables. However, this is not really surprising given the large number of dummy variables included in these regressions. Apart from bilateral distance, all of our explanatory variables are guest team and/or home team specific and are, therefore, likely to be captured by the corresponding fixed effects (as well as the interaction terms with seasons). This, in turn, makes it difficult to isolate the pure impact of these variables on team performance. As can be seen from the lower block of Table 2, however, the additional fixed effects (interaction terms and round effects) are highly significant throughout. Further, a likelihood ratio test based on the likelihood ratios of the last line in Table 2 tends to reject the restrictions underlying the nested Models A (i.e., that the interaction terms and the round effects are jointly equal to zero). Therefore, we would generally prefer Models B over Models A. Nevertheless, Table 2 also points to the fact that the impact of distance and its square is stable over both model types, so that it does not make a real difference which model type is chosen to illustrate the importance of distance on team performance.

For conceded goals, we find, as expected, a significant and non-monotonic impact of distance. Our estimation results suggest that the defensive ability of a team is negatively associated with distance. The significant quadratic distance term indicates that the negative impact of distance becomes less important as the distance to the foreign playing venue becomes larger.

From the coefficient vectors of Table 2 we are able to calculate the marginal effects of distance. For this purpose, we take the first derivative of (2) with respect to the distance variable x_{ij}

$$\frac{\partial \mathrm{E}(y_{ij,rs}|\mathbf{X})}{\partial x_{ij}} = \exp(\mathbf{X}\widehat{\boldsymbol{\beta}})(\widehat{\beta}_{1,x_{ij}} + 2\widehat{\beta}_{2,x_{ij}} x_{ij}). \tag{3}$$

Table 2: Estimation results

Variable	Scored goals		Conceded goals		Goal difference	
	Model *A*	Model *B*	Model *A*	Model *B*	Model *A*	Model *B*
Distance	−0.154	−0.156	0.457***	0.350*	−0.148**	−0.115*
	(0.233)	(0.227)	(0.193)	(0.185)	(0.065)	(0.063)
Distance^2	0.156	0.103	−0.466*	−0.421*	0.154*	0.128*
	(0.299)	(0.287)	(0.249)	(0.236)	(0.085)	(0.080)
Match attendances to capacity	0.014	−0.056	0.049	−0.128	−0.009	0.024
	(0.081)	(0.103)	(0.062)	(0.080)	(0.022)	(0.028)
Opponent scored goals	−0.013***	−0.012**	0.005*	−0.021***	−0.004***	0.003**
	(0.004)	(0.005)	(0.003)	(0.004)	(0.001)	(0.001)
Opponent conceded goals	0.013***	−0.014***	−0.005	0.000	0.004***	−0.002*
	(0.004)	(0.005)	(0.003)	(0.004)	(0.001)	(0.001)
Number of coaches per season	−0.019	0.137***	0.050***	−0.052*	−0.018***	0.039***
	(0.024)	(0.036)	(0.018)	(0.027)	(0.007)	(0.009)
Observations	6,389	6,389	6,389	6,389	6,389	6,389
Pseudo R^2	0.022	0.074	0.024	0.072	0.012	0.030
Cragg-Uhler R^2	0.063	0.201	0.079	0.219	0.051	0.119
Fixed Effects						
Team	147.95***	65.92***	157.31***	126.72***	255.46***	135.58***
Opponent	97.64***	67.74***	178.84***	77.63***	211.16***	92.09***
Season	37.54**	19.85	58.94***	46.77***	43.68***	32.03**
Team×Season	-	533.82***	-	585.24***	-	621.80***
Opponent×Season	-	518.87***	-	591.208***	-	593.61***
Round	-	89.43***	-	83.31***	-	46.09
Log-likelihood	−8838.2	−8364.0	−10242.1	−9738.5	−13463.8	−13463.8

Notes: Parameter estimates for fixed effects and the constant are not reported. White (1990) robust standard errors in parentheses. *** Significant at the 1% level, ** Significant at the 5% level, * Significant at the 10% level.

Holding all control variables (including the fixed effects) constant at their mean values, we derive a marginal effect for conceded goals in Model A of about 0.0019, evaluated at the mean value of distance (measured in 1,000 kilometers). In other words, an additional distance of 100 kilometers to the playing venue is associated with 0.019 additional conceded goals. The corresponding marginal effects for other locations in the distribution of distance are reported in Table 3. Accordingly, the marginal effect of distance on conceded goals turns out to be positive for most parts of the distance distribution. The exceptions are distances above the 3$^{\text{rd}}$ quartile, where we obtain negative marginal effects.

Setting (3) equal to zero allows to compute the 'critical' distance, where the marginal effect of distance on conceded goals changes from positive to negative. For instance, considering the parameter estimates from Model A, we obtain a critical distance of $\tilde{x}_{ij} = -\frac{\widehat{\beta}_{1,x_{ij}}}{2\widehat{\beta}_{2,x_{ij}}} = -\frac{0.457}{2(-0.466)} \approx 0.49$ (= 490 kilometers) for conceded goals. The corresponding value for Model B is around 416 kilometers. In other words, the maximum impact of distance on conceded goals is roughly around 450 kilometers.

Regarding scored goals, we are not able to identify any significant effects of distance (see Tables 2 and 3). The distribution of scored and conceded goals depicted in Figure 1 might help to explain this finding. There, a decrease in team performance can be illustrated graphically by a movement from the left to the right for goals conceded, and by a movement in the opposite direction for scored goals. Therefore, for scored (conceded) goals we would expect an increase (decrease) in the share of a low number of goals as the distance between the home location and the foreign playing venue becomes larger. However, in the case of scored goals we have a relatively large share of zeroes (around 33 percent), forming a lower bound for a decrease in a team's offensive performance. This, together with a much lower variation for scored goals than for conceded ones, might induce upward biased standard errors and, therefore, insignificant estimation results.

Given the ambiguous results for scored goals, it might be useful to focus on the difference between scored and conceded goals. A positive or at least a balanced goal difference can be seen as the ultimate aim of a football team. The last two columns of Table 2 suggest that distance affects the goal difference in a negative way. Further, we observe a significantly positive

Table 3: Marginal effects (impact of 100 kilometers in additional distance)

	Distance	**Scored goals**		**Conceded goals**		**Goal difference**	
	(in km)	Model *A*	Model *B*	Model *A*	Model *B*	Model *A*	Model *B*
Mean	368.3	−0.004	−0.008	0.019	0.006	−0.022	−0.014
		(0.620)	(0.297)	(0.067)	(0.517)	(0.116)	(0.324)
Median	364	−0.005	−0.009	0.020	0.007	−0.023	−0.014
		(0.608)	(0.292)	(0.058)	(0.479)	(0.102)	(0.300)
Lower 25 percent quartile	220	−0.010	−0.012	0.042	0.027	−0.051	−0.038
		(0.471)	(0.340)	(0.008)	(0.079)	(0.015)	(0.065)
Upper 75 percent quartile	543	0.002	−0.005	−0.008	−0.018	0.013	0.015
		(0.904)	(0.721)	(0.648)	(0.288)	(0.586)	(0.498)
Lower 1 percentile	15	−0.017	−0.017	0.075	0.055	−0.092	−0.072
		(0.507)	(0.484)	(0.017)	(0.059)	(0.024)	(0.064)
Upper 99 percentile	774	0.010	0.0003	−0.044	−0.049	0.059	0.053
		(0.730)	(0.991)	(0.212)	(0.130)	(0.208)	(0.222)

Notes: p-values in parentheses.

parameter estimate for squared distance, suggesting that the negative impact of distance is dampened with a playing venue farther away. As can be seen from Table 3, an increase in distance of 100 kilometers is associated with a decrease in the goal difference by about -0.022, evaluated at the mean of distance (and at the mean of all control variables, including the fixed effects). Again, the marginal effect of distance changes its sign in the upper tail of the distance distribution (see Table 3). Setting (3) equal to zero for the parameter estimates of the goal difference, we derive critical distances of 481 kilometers (Model A) and 450 kilometers (Model B), respectively. These values are lying within the range of critical distances that are derived for conceded goals.

4 Conclusions

The importance of distance on individual behavior is well documented in the economic literature. This paper analyzes the role of distance on professional team performance. More precisely, we argue that a sports team might be less successful if the playing venue is relatively far away from the home location. To test this hypothesis empirically we use data from the German Football Premier League (Erste Bundesliga), including data of 38 professional football teams between the playing seasons 1986-87 and 2006-07. Team performance is measured by the propensity to score and to concede goals and by the difference between scored and conceded goals, which might be viewed as the ultimate aim of a football team. Thereby, we only focus on away games. Empirically, we apply a standard gravity model as proposed by the empirical trade literature, and extend this framework to event count data (i.e., goals within a specific time period). To isolate the impact of distance, we control for variables that are typically viewed as decisive for the offensive and defensive performance of a football team (e.g., the offensive and defensive strength of the opponent).

Our empirical findings lend support to the view that distance exerts a systematic influence on the performance of professional sports teams. In particular, we find a significant and non-monotonic impact of distance on the defensive abilities of a team. Regarding the offensive abilities, we are not able to identify any significant effects. However, focusing on the difference between scored and conceded goals as an overall measure of team performance, our empirical results tend to confirm that team performance is systematically influenced if the foreign playing venue is relatively far away from the home location. Overall, we may conclude that distance is decisive for the output of professional sports teams. Obviously, this result is in accordance with the empirical evidence from other fields of economics.

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A Appendix

A.1 Data sources

Team performance:

http://www.mbovin.com/soccerdb (July 2008)

http://www.fussballdaten.de/ (July 2008)

http://t-online.sport-dienst.de/ (July 2008)

Stadium capacities, match attendances per game, number of coaches per season:

http://www.dfb.de (July 2008)

http://t-online.sport-dienst.de/ (July 2008)

http://www.duisburgweb.de/Fussballweb/bl_spielzeiten_ab1963.htm (July 2008)

http://mlucom6.urz.uni-halle.de/~bnra5/fussball/bundliga/ (June 2004)

Distance:

http://maps.google.at (July 2008)

A.2 Tables

Table A1: Descriptive statistics (away games)

Variable	Observations	Mean	Std. Dev.	Min	Max
Scored goals	6,389	1.158	1.130	0	9
Conceded goals	6,389	1.713	1.357	0	8
Goal difference	6,389	−0.554	1.800	-7	8
Distance	6,389	368.328	201.755	0	805
Match attendances to capacity	6,389	0.678	0.270	0.064	1.098
Opponent scored goals	6,389	6.325	3.283	0	20
Opponent conceded goals	6,389	6.630	3.348	0	23
Number of coaches per season	6,389	1.219	0.528	1	4

Table A2: Distance matrix (all distances in kilometers)

Opponents		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
1.FC Kaiserslautern	(1)	-	239	302	70	78	.	436	254	297	406	654	331	281	568	117	696	42	603	277
1.FC Koeln	(2)	239	-	406	258	181	.	197	19	58	573	573	96	64	569	189	668	279	422	39
1.FC Nuernberg	(3)	302	406	-	367	259	476	435	412	641	168	435	438	473	310	225	439	339	608	443
1.FC Saarbruecken	(4)	70	258	367	-	.	.	.	277	315	486	.	348	299	636	184	.	.	.	.
1.FSV Mainz 05	(5)	78	181	259	.	-	242	345	189	.	426	.	248	239	.	44	614	.	.	.
Alemannia Aachen	(6)	.	.	476	.	242	-	258	80	.	643	.	156	64	.	261	727	.	.	.
Arminia Bielefeld	(7)	436	197	435	.	345	258	-	184	.	601	.	116	212	.	318	485	.	253	181
Bayer 04 Leverkusen	(8)	254	19	412	277	189	80	184	-	60	579	561	84	65	584	196	655	299	411	30
Bayer 05 Uerdingen	(9)	297	58	641	315	.	.	.	60	-	637	567	68	30	590	254	.	337	397	26
Bayern Muenchen	(10)	406	573	168	486	426	643	601	579	637	-	584	605	625	460	392	589	458	774	609
Blau Weiß 90 Berlin	(11)	654	573	435	.	.	.	.	561	567	584	-	491	593	.	543	.	700	.	557
Borussia Dortmund	(12)	331	96	438	348	248	156	116	84	68	605	491	-	98	515	220	587	369	342	69
Borussia M'Gladbach	(13)	281	64	473	299	239	64	212	65	30	625	593	98	-	615	254	682	321	422	30
Dynamo Dresden	(14)	568	569	310	636	.	.	.	584	590	460	.	515	615	-	458	.	.	.	581
Eintracht Frankfurt	(15)	117	189	225	184	44	.	318	196	254	392	543	220	254	458	-	587	156	492	226
Energie Cottbus	(16)	696	668	439	.	614	727	485	655	.	589	.	587	682	.	587	-	.	413	.
FC Homburg	(17)	42	279	339	.	.	.	.	299	337	458	700	369	321	.	156	.	-	643	323
FC St. Pauli	(18)	603	422	608	.	.	.	253	411	397	774	.	342	422	.	492	413	643	-	397
Fortuna Duesseldorf	(19)	277	39	443	.	.	.	181	30	26	609	557	69	30	581	226	.	323	397	-
Hamburger SV	(20)	603	422	608	671	521	488	253	411	379	774	284	342	422	498	492	413	643	.	397
Hannover 96	(21)	458	295	466	.	377	354	112	282	291	632	.	213	309	.	349	378	499	159	.
Hansa Rostock	(22)	783	603	626	.	694	.	425	593	579	773	.	525	607	420	673	356	.	191	580
Hertha BSC Berlin	(23)	654	573	435	.	580	640	398	561	567	584	.	491	593	.	543	129	.	284	557
Karlsruher SC	(24)	90	300	251	195	.	.	448	307	362	286	.	351	343	548	138	.	167	623	336
MSV Duisburg	(25)	305	70	465	.	232	.	171	55	26	632	.	61	51	580	248	.	.	374	32
SC Freiburg	(26)	214	432	383	.	278	.	582	439	482	413	.	484	479	682	271	.	.	756	469
SpVgg Unterhaching	(27)	442	599	.	.	.	.	622	608	.	12	.	627	.	.	415	609	.	.	.
SSV Ulm 1846	(28)	280	.	.	.	.	.	517	462	.	151	.	502	.	.	290	.	.	.	.
SV Waldhof Mannheim	(29)	66	241	240	.	.	.	.	247	300	345	617	291	284	.	79	.	106	565	281
Schalke 04	(30)	317	79	469	348	259	147	141	66	52	634	517	35	80	558	250	611	369	353	45
Stuttgarter Kickers	(31)	191	364	209	.	.	.	.	370	430	220	.	416	410	508	203	.	.	665	401
TSV 1860 Muenchen	(32)	406	573	168	.	.	.	601	579	637	0	.	605	625	460	392	589	.	774	609
VfB Leipzig	(33)	498	498	281	.	.		.	485	.	430		416	516	114	389	.	.	.	.
VfB Stuttgart	(34)	191	364	209	269	212	422	492	370	430	220	631	416	410	508	203	637	241	665	401
VfL Bochum 1848	(35)	321	86	454	342	253	136	139	72	48	621	513	21	77	539	236	610	363	350	49
VfL Wolfsburg	(36)	482	374	454	.	398	437	195	364	.	601	.	296	397	.	371	320	.	223	.
Wattenscheid 09	(37)	321	82	462	335	.	.	.	67	43	628	.	28	70	550	242	.	.	359	43
Werder Bremen	(38)	548	313	580	573	473	381	188	301	287	747	390	231	313	470	439	484	595	121	285

Opponents		(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)	(29)	(30)	(31)	(32)	(33)	(34)	(35)	(36)	(37)	(38)
1.FC Kaiserslautern	(1)	603	458	783	654	90	305	214	442	280	66	317	191	406	498	191	321	482	321	548
1.FC Koeln	(2)	422	295	603	573	300	70	432	599	.	241	79	364	573	498	364	86	374	82	313
1.FC Nuernberg	(3)	608	466	626	435	251	465	383	.	.	240	469	209	168	281	209	454	454	462	580
1.FC Saarbruecken	(4)	671	.	.	.	195	.	.	.	.	.	348	.	.	.	.	342	.	335	573
1.FSV Mainz 05	(5)	521	377	694	580	.	232	278	.	.	.	259	.	.	.	212	253	398	.	473
Alemannia Aachen	(6)	488	354	.	640	.	.	.	.	.	.	147	.	.	.	422	136	437	.	381
Arminia Bielefeld	(7)	253	112	425	398	448	171	582	622	517	.	141	.	601	.	492	139	195	.	188
Bayer 04 Leverkusen	(8)	411	282	593	561	307	55	439	608	462	247	66	370	579	485	370	72	364	67	301
Bayer 05 Uerdingen	(9)	397	291	579	567	362	26	482	.	.	300	52	430	637	.	430	48	.	43	287
Bayern Muenchen	(10)	774	632	773	584	286	632	413	12	151	345	634	220	0	430	220	621	601	.	747
Blau Weiß 90 Berlin	(11)	284	.	.	.	.	.	.	.	.	617	517	.	.	.	631	513	.	.	390
Borussia Dortmund	(12)	342	213	525	491	351	61	484	627	502	291	35	416	605	416	416	21	296	.	231
Borussia M'Gladbach	(13)	422	309	607	593	343	51	479	.	.	284	80	410	625	516	410	77	397	70	313
Dynamo Dresden	(14)	498	.	420	.	548	580	682	.	.	.	558	508	460	114	508	539	.	550	470
Eintracht Frankfurt	(15)	492	349	673	543	138	248	271	415	290	79	250	203	392	389	203	236	371	242	439
Energie Cottbus	(16)	413	378	356	129	.	.	.	609	.	.	611	.	589	.	637	610	320	.	484
FC Homburg	(17)	643	499	.	.	167	.	.	.	.	106	369	.	.	.	241	363	.	.	595
FC St. Pauli	(18)	0	159	191	284	623	374	756	.	.	565	353	665	774	.	665	350	223	359	121
Fortuna Duesseldorf	(19)	397	.	580	557	336	32	469	.	.	281	45	401	609	.	401	49	.	43	285
Hamburger SV	(20)	-	159	191	284	623	374	756	798	693	565	353	665	774	396	665	350	223	359	121
Hannover 96	(21)	159	-	331	291	480	269	614		.	425	238	523	632	.	523	237	88	.	132
Hansa Rostock	(22)	191	331	-	224	805	557	.	799	.	.	562	.	773	.	.	533	401	531	304
Hertha BSC Berlin	(23)	284	291	224	-	672	543	805	613	624	.	517	.	584		631	513	229	528	390
Karlsruher SC	(24)	623	480	805	672	-	358	139	.	.	65	370	79	286	518	79	367	503	369	570
MSV Duisburg	(25)	374	269	557	543	358	-	491	651	505	.	30	423	632	481	423	36	348	33	262
SC Freiburg	(26)	756	614	.	805	139	491	-	447	286	.	502	.	413	652	206	501	635	503	704
SpVgg Unterhaching	(27)	798	.	799	613	.	651	447	-	175	.	659	.	12	.	254	640	616	.	771
SSV Ulm 1846	(28)	693	.	.	624	.	505	286	175	-	.	532	.	151	.	93	.	570	.	666
SV Waldhof Mannheim	(29)	565	425	.	.	65	.	.	.	.	-	311	130	.		130	305	.	.	511
Schalke 04	(30)	353	238	562	517	370	30	502	659	532	311	-	436	634	459	436	15	321	6	243
Stuttgarter Kickers	(31)	665	523	.	.	79	423	.	.	.	.	436	-	.	.	0	432	.	436	635
TSV 1860 Muenchen	(32)	774	632	773	584	286	632	413	12	151	.	634	.	-	.	220	621	601	.	747
VfB Leipzig	(33)	396	.	.	.	518	481	652	.	.	.	459	.	.	-	477	.	.	451	369
VfB Stuttgart	(34)	665	523	.	631	79	423	206	254	93	130	436	0	220	477	-	432	533	436	635
VfL Bochum 1848	(35)	350	237	533	513	367	36	501	640	.	305	15	432	621	.	432	-	317	6	240
VfL Wolfsburg	(36)	223	88	401	229	503	348	635	616	570	.	321	.	601	.	533	317	-	.	196
Wattenscheid 09	(37)	359	.	531	528	369	33	503	.	.	.	6	436	.	451	436	6	.	-	252
Werder Bremen	(38)	121	132	304	390	570	262	704	771	666	511	243	635	747	369	635	240	196	252	-

Notes: '-' indicates the diagonal element. '.' denotes that no game between the two teams took place within the sample period.

Table A3: Correlation matrix (away games)

Variable		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Scored goals	(1)	1.0000							
Conceded goals	(2)	−0.0396	1.0000						
Goal difference	(3)	0.6576	−0.7788	1.0000					
Distance	(4)	−0.0066	0.0162	−0.0163	1.0000				
Match attendances to capacity	(5)	0.0238	−0.0306	0.0380	−0.0253	1.0000			
Opponent scored goals	(6)	−0.0543	0.0802	−0.0946	0.0194	0.0745	1.0000		
Opponent conceded goals	(7)	0.0677	−0.0479	0.0786	0.0017	−0.1433	0.1679	1.0000	
Number of coaches per season	(8)	−0.0255	0.0415	−0.0473	−0.0293	0.0185	0.0701	0.0657	1.0000

A.3 Figures

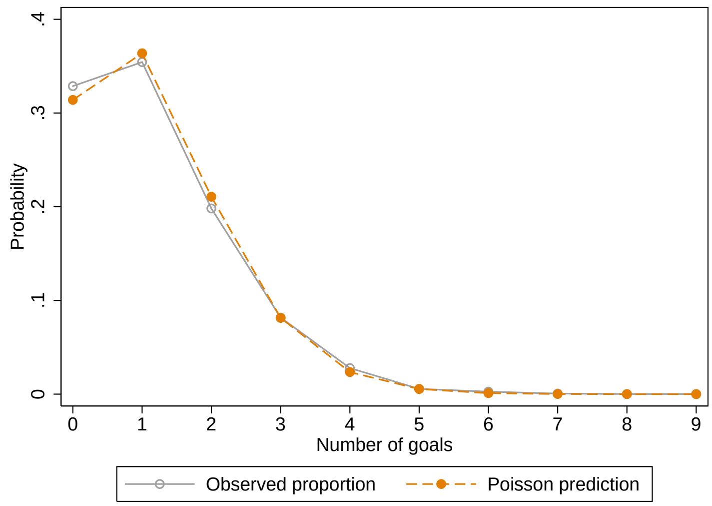

Figure A1: Observed and predicted probabilities, scored goals ($\widehat{\lambda} = 1.16$)

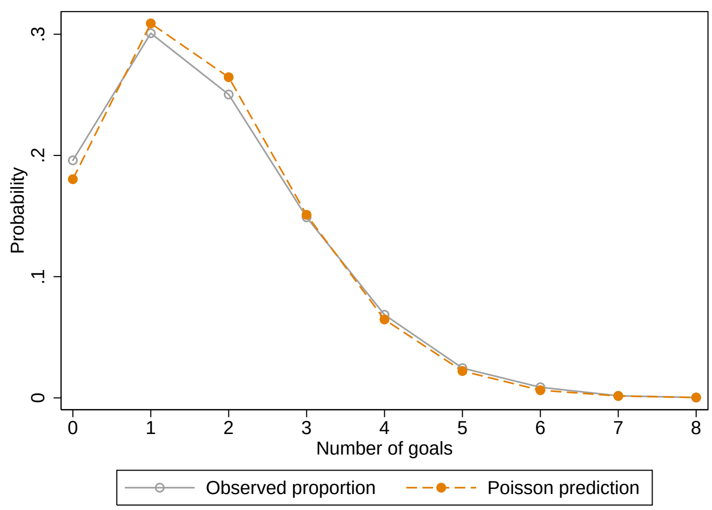

Figure A2: Observed and predicted probabilities, conceded goals ($\widehat{\lambda} = 1.71$)

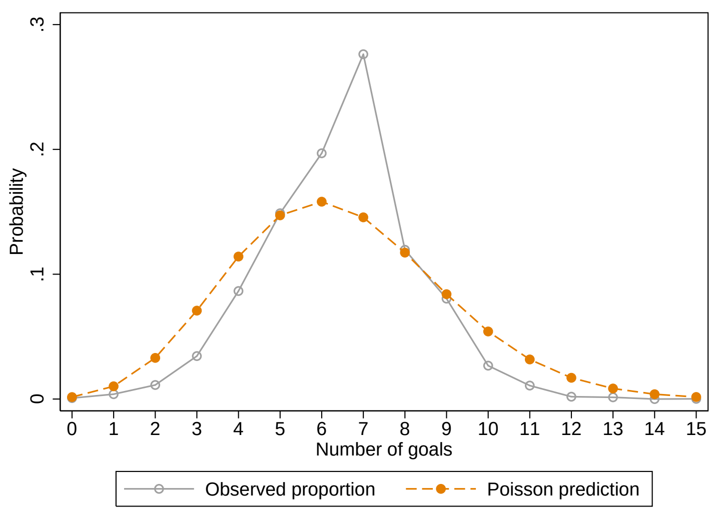

Figure A3: Observed and predicted probabilities, goal difference ($\widehat{\lambda} = 6.45$)

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Harald Oberhofer, Tassilo Philippovich and Hannes Winner

Distance Matters! Evidence from Professional Team Sports

Abstract
This paper assesses the role of distance in professional team sports, taking the example of football (soccer). We argue that a team's performance in terms of scored and conceded goals decreases with the distance to the foreign playing venue. To test this hypothesis empirically, we investigate 6,389 away games from the German Football Premier League ('Erste Deutsche Bundesliga') between the playing seasons 1986-87 and 2006-07. We find that distance contributes significantly in explaining a guest team's propensity to concede goals, but not so for scoring goals. Focusing on the difference between scored and conceded goals ('goal difference') as a measure of the overall success of a football team, we observe a significant and non-monotonic impact of distance on team performance.

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