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MANAGERIAL EFFICIENCY IN GERMAN TOP LEAGUE SOCCER

A Stochastic Frontier Analysis of Club Performances on and off the Pitch

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ABSTRACT. This study applies stochastic frontier analytic techniques in the estimation of sporting production functions. As ex ante input factors, we use pre-seasonal estimates of wage bills of players and coaches that are transformed during the production process of a season into ex post pecuniary revenues and sporting success. While in the case of athletic output we find a robust pattern of technical efficiency over subsequent seasons, the estimates based on economic output highlight the instability of the German soccer industry.

Keywords: soccer economics, sporting production function, stochastic frontier

JEL classification: L83, C21, D24

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1. Introduction

European professional soccer has shown dynamic economic growth over the past decade. Some of the top clubs (companies) invest in excess of 50 million EUR annually in their players and management as they vie for success on and off the pitch. Human capital, which is comprised predominantly of players and coaches, is without doubt the central factor of production. The economics of soccer is growing parallelly to the economic significance of the industry. Economists prefer to measure performance in relative rather than absolute terms. As do the fans: "They made the most of what they had" or "they didn't live up to their potential" is typical commentary as to the seasonal performance of a team. Behind this stands the theoretical concept of the production function of a soccer corporation. Clubs invest in players, coaches, and management in order to succeed in the several competitions they take part and thereby increase revenue from the gate, broadcasting rights, merchandising and sponsoring. Of course most clubs still consider success on the pitch and the glory of victory as their main business objective. However, clubs are also focussing more and more on the economic ramifications of their striving for success: Shareholders expect a risk-adequate return on their investment, creditors require solid cash flow and interest coverage. Given that for all clubs in a national league the same production technology applies, the managerial efficiency of each can be measured in terms of success relative to their potential.

There exists a strand of recent literature on sporting production functions, which differs in three primary characteristics: the league(s) under investigation, the choice of input and output variables[1], and the statistical technique or econometric strategy[2]

[1] For example, success of the single coach vs. success of the team (firm) as the dependent variable.

[2] Several authors, like, e.g., Haas (2003) for US Major League Soccer, apply the non-parametric, deterministic technique of Data Envelopment Analysis (DEA) to measure (productive) efficiency in the context of team performance. However, as no one would seriously deny that a certain amount of chance or statistical noise influences the results of football matches (as the central element of sporting and economic success of the clubs), we abstract from considering the deterministic DEA approach in the present study.

followed. Most of this work has dealt with U.S. major league sports (primarily Major League Baseball), as pioneered by Rottenberg (1956). As for soccer the focus so far has been on the English F.A. Premiership; see Carmichael *et al.* (1999), Dawson *et al.* (2000), Dobson and Goddard (2001, Ch. 5, Sect. 5.2-5.3), and Gerrard (2001). Carmichael *et al.* (1999) estimate a team's performance production function using OLS regressions only. The same holds for Gerrard (2001) who concentrates on the win-ratios of the coaches working in the Premier League from 1992-1998. The OLS approach falls short in that only an average efficiency production function is estimated not the full scale one. Efficiency in this case can only be assessed relative to the "average club" not to the individual full efficiency benchmark. Dawson *et al.* (2000) compare the efficiency rankings from an OLS regression to those resultant from their stochastic frontier analytic estimates. For the years 1992-1998, they examine what coaches could make of a certain amount of playing talent in terms of success in the Premiership.

Our study is the first to look at the German top league, i.e. the *Erste Bundesliga*, using stochastic frontier analysis. Inputs are the *ex ante* fixed wages for the players and the coach, while several team- and season-specific characteristics are controlled for. Most studies measure success on the pitch in terms of league performance: As it is obvious that clubs base their investment decisions to a high degree on the *a priori* knowledge whether or not they participate in the international competitions, we define an output variable "score" (henceforth *SCO*). *SCO* summarizes the success of German *Bundesliga*[3] clubs in all competitions in one value. Economic output is measured in terms of revenues. We look at the two subsequent seasons 1999/00 and 2000/01 assessing the team performances separately for each season. Therefore, we investigate a pooled one-period-model with the teams' pre-season market investments in players and coaches judged by output the following summer; cf. Dawson *et al.*

[3] We use the term *Bundesliga* to denote the German top league, i.e. *Erste Bundesliga*. Actually, there exist the *Erste Bundesliga* and the *Zweite Bundesliga* (both containing 18 teams, respectively). However, due to its common usage and since some of the analyzed teams were top league members only in one of the investigated seasons, it seems better not to multiply terms.

(2000). Analyzing a two season pool, we face 36 observations for the 21 *Bundesliga* teams participating in one or both years. Investigating which teams consistently operated efficiently or inefficiently in these two subsequent seasons from 1999-2001 is a first step in examining the development or constancy of efficiency. Scarcity of the relevant *Bundesliga* data so far impedes a longer horizon, the implication of autoregressive parts in our regressions, as well as the estimation of time-dependent efficiencies and panel data models.[4] All the more, our study aims to shed some light on the managerial transformation process from human capital to measurable output - a "black box" and source of weekly speculation - in German top league soccer.

The remainder of the paper is structured as follows: Section 2 describes the dataset used, preliminaries, and applied methods. Section 3 reports our findings on sporting and economic efficiency, respectively. And finally, Section 4 concludes.

2. Data and Stochastic Production Frontier Methodology

2.1 Choice and Adjustment of Data

In the present study productive output of soccer clubs is measured not only by the success on the pitch but also by adjusted total revenues (henceforth *REV*). In contrast to existing related work, we quantify athletic output not only for the national but also for the international European competitions. The following paragraphs focus on the outline of our pecuniary variables of investigation. For detail on our sporting output measure *SCO* the reader is referred to Appendix A.1. While there is an amazing amount of data available on sporting results and performances for most European professional national soccer leagues, economic data on soccer clubs is generally scarce. One notable exception is England, where many soccer companies are listed on stock exchanges and therefore must by law publish their annual reports. In Germany the only club to undertake an initial public offering until the end of 2002 was Borussia Dortmund. At this time an additional seven clubs were constituted joint-stock companies. However, this does not imply that they necessarily have to

[4] This problem, especially, applies to data for *ex ante* wages.

make their balance sheets available to the public. This is one reason we choose figures of revenues rather than, e.g., (operating) profits. Operating profits are "defined" in quite different ways by managements before presentation in the general meetings of the club members. Furthermore most club managements do not follow a stringent shareholder value orientation. Ultimately, this is the result of generic moral hazard: The central incentive of management is the generation of glory, the result of wins and club titles, and in so doing maximizing their own reputation or popularity rather than the club's profits. Where available, data for total revenues, for the respective season, are taken from the income statements of the clubs - otherwise from the studies of the WGZ-Bank (2001, 2002). However, it would be desirable to isolate the output that depends exclusively on the performance and management in the respective season. Identifying exact marginal gate revenues, marginal merchandising income, or the like is impossible. The adjustment suggested in the following is a step in the direction to unravel performance-dependent output. The league's income from TV-broadcasting rights by the end of the last decade was as follows: In 1999/00 every club in the *Bundesliga* received a fixed TV-rights-transfer of approximately 6 million EUR. In 2000/01 a new TV-broadcasting contract nearly doubled the two top leagues' income from 212 million EUR to 386 million EUR a year. For this substantial additional cash-flow, the clubs agreed on creating a variable income component that should for more than 80 percent (i.e. 83%) depend on the respective *Bundesliga*-club's finishing positions in the three preceding years. The rest was hooked to the performances in the respective season. To take this effect into account, we subtract from a club's revenues the respective certain pay-off through TV-broadcasting rights at the beginning of the season, i.e. the fixed and the 3-year-payments.

Scarcity of balance sheet data for German clubs explains why we base our econometric analysis of REV and SCO mainly on wage bill data, rather than on data on equity or total capital employed. However, wages can only reasonably proxy management-installed human capital if they do not include bonus payments and premia that are received during and depend on the productive process, i.e. the intra-seasonal performances. This leads us to use pre-seasonal estimates of the wage sums of players (*PLW*) and coaches (*COW*) instead of end-of-season data due to the fact that the former are independent of a teams future intra-seasonal success. These data are published at the beginning of each season by the German sports magazine *Der Kicker*. They capture usable means of production. Their installation (bargains and recruitments on the transfer markets, etc.) and transformation into measurable output are the chief task of the manager.[5]

2.2 The Black Box: Productive Process, Technology and Returns to Scale

The present section outlines and reports our benchmark estimates, where we implicitly assume that all clubs either produce efficiently or deviate from an average efficiency by noise only. Besides the above outlined two elementary productive input factors, we consider a range of dummy variables to control for different characteristics in the course of the managerial "black box"-production process. The impact of the following, mainly qualitative, variables on the economic and athletic output of our sample's clubs is investigated: (i) participation in an international competition (*INT*), i.e. in the UEFA-Cup (*UEF*) or the UEFA Champions League (*CHL*), (ii) fan potential according to the recent UFA study (*UFA*)[6], (iii) net intra-seasonal transfers of players (*NPL*), (iv) the intra-seasonal signing up of a new coach (*NCO*),[7] and finally (v) a dummy to control for a change of technological level, in the sense of the popular Solow residual, from season 1999/00 to 2000/01 (*S01*).

To move beyond the slogan of quantitatively assessing some sort of *ad hoc* produc-

[5]Cf. the comprehensive discussion of this argumentation on the transformation of *ex ante* inputs into *ex post* performance in the context of sporting production functions in Dawson *et al.* (2000).

[6]See UFA Sports GmbH (2000), where the brand potential of German *Bundesliga* clubs is assessed on the base of interviews from a sample identifying 21.5 million soccer fans in Germany. Among a set of other questions, participants were asked for their (main) supporting of a certain club. Unfortunately, the study reports the first nine most frequently mentioned *Bundesliga* clubs only. To overcome the problem of a truncated ordinal regressor, we decided for a binary top-brand rather than a categorial dummy.

[7]Note, in his study based on data of the Dutch national soccer league, Koning (2003) finds that intra-seasonal firing and hiring of coaches does not improve team performance.

tion process, we test the straightforward Cobb-Douglas technology $Y = A\left(H^p\right)^{\alpha}\left(H^c\right)^{\beta}$, where H^p and H^c denote *ex ante* human capital of players and coaches, respectively, against a more flexible translog specification. In log-linearized form, we consider:

$$y_i = \beta_0 + \beta_1 h_i^p + \beta_2 h_i^c + \sum_{j=1}^{C} \gamma_j Q_{j,i} + \varepsilon_i \tag{1}$$

and

$$y_i = \beta_0 + \beta_1 h_i^p + \beta_2 h_i^c + \frac{1}{2}\beta_3\left(h_i^p\right)^2 + \frac{1}{2}\beta_4\left(h_i^c\right)^2 + \beta_5 h_i^p h_i^c + \sum_{j=1}^{C} \gamma_j Q_{j,i} + \varepsilon_i, \tag{2}$$

where minor letters denote expressions in natural logs, $\beta_0 = \ln\left(A_i\right), \beta_1 = \alpha, \beta_2 = \beta$, etc. ε_i represents an i.i.d. normal error term and Q a matrix of $j = 1, ..., C$ control variables. While the former specification (1) imposes constant elasticities of substitution, the linearized translog production function (2) obviously nests Cobb-Douglas and allows for flexible elasticities. Actually, we consider $C = 5$ control variables as given by (i) to (v) above. Furthermore, we use *ex ante* wage bills of players (*PLW*) and coaches (*COW*) to proxy H^p and H^c, respectively. As output variables Y, we consider *REV* and *SCO*. For detail on the construction and sources of variables as well as descriptive statistics of our non-dummy variables see Section 2.1 and the Appendix.

As can be seen from Table 1, an F-Test on the joint hypothesis $\beta_3 = \beta_4 = \beta_5 = 0$ is on all conventional levels of significance and for both dependent variables, i.e. ln(*REV*) and ln(*SCO*), unable to reject the null of a Cobb-Douglas (CD) technology. Obviously, neither the null of a CD-type production function nor the one of homoskedasticity can be rejected on the one percentage level of significance.

Table 1. F- (CD vs. Translog) and White-Test for pooled regressions: 99/00 and 00/01[8]

Dependent variable:	ln(*REV*)	ln(*SCO*)	
F-Statistics:	2.112 (0.121)	0.797 (0.505)	for H_0: Cobb-Douglas technology
F-Statistics (White):	1.260 (0.314)	0.620 (0.753)	for H_0: Homoskedasticity

Note: p-values in parentheses.

Table 2. Results for pooled regressions: 99/00 and 00/01; baseline production function: Cobb Douglas type technology and no efficiency decomposition of error terms

Table 2 (a) Dependent variable is economic output, i.e. ln(*REV*)[9]

spec.	*CONST*	ln(*PLW*)	ln(*COW*)	*UFA*	*NPL*	*NCO*	*CHL*	*S01*
S1	0.325 (1.051)	1.169*** (9.863)						
S2	0.944 (1.566)	0.974*** (4.823)	0.186 (1.194)					
S3	1.960*** (3.069)	0.542** (2.341)	0.380** (2.469)	0.380*** (2.993)				
S4	2.083*** (3.202)	0.524** (2.255)	0.405** (2.597)	0.458*** (2.903)	-.122 (-.996)			
S5	2.062*** (3.133)	0.539** (2.285)	0.400** (2.531)	0.443*** (2.746)	-.103 (-.806)	-.090 (-.624)		
S6	2.246*** (4.096)	0.410** (2.065)	0.313** (2.354)	0.421*** (3.144)	-.145 (-1.36)	-.088 (-.734)	0.592*** (3.811)	
S7	2.083*** (3.954)	0.516** (2.640)	0.294** (2.326)	0.385*** (3.000)	-.124 (-1.22)	-.052 (-.456)	0.515*** (3.389)	-.211** (-2.04)

Fit		S1	S2	S3	S4	S5	S6	S7
adj. R^2		0.733	0.736	0.806	0.787	0.785	0.850	0.865
log L		-17.0	-16.3	-11.8	-11.3	-11.0	-3.78	-1.27

Note: *, **, *** denotes significance on 10, 5, 1% level of significance; t-values given in parentheses.

[8]Note, as will be outlined later, the model for economic output, i.e. for the endogenous variable ln(*REV*), considers *UFA*, *CHL*, and *S01*, while the model for ln(*SCO*) controls for participation in international cups (*INT*) only.

[9]Note, we also considered UEFA cup participation (*UEF*) as well as the more general participation in international cups ($INT = CHL + UEF$). However, we obtain best results for the specifications of Table 2 (a), in terms of significance, by including exclusively *CHL*.

Table 2 (b) Dependent variable is athletic output, i.e. ln(*SCO*)

spec.	*CONST*	ln(*PLW*)	ln*(COW)*	*UFA*	*NPL*	*NCO*	*INT*	*S01*
S1	0.392 (1.223)	0.593*** (4.820)						
S2	0.639 (1.002)	0.515*** (2.416)	0.073 (0.449)					
S3	1.222 (1.653)	0.268 (1.000)	0.185 (1.040)	0.270 (1.484)				
S4	1.388* (1.855)	0.243 (0.910)	0.219 (1.221)	0.253 (1.393)	-.165 (-1.17)			
S5	1.328* (1.812)	0.285 (1.087)	0.204 (1.159)	0.210 (1.173)	-.112 (-0.78)	-.252 (-1.55)		
S6	1.284** (1.978)	0.227 (0.974)	0.091 (0.573)	0.103 (0.634)	-.171 (-1.33)	-.253* (-1.76)	0.465*** (3.040)	
S7	1.375*** (2.110)	0.167 (0.701)	0.109 (0.680)	0.126 (0.774)	-.182 (-1.42)	-.277** (-1.92)	0.475*** (3.114)	0.139 (1.113)
Fit		S1	S2	S3	S4	S5	S6	S7
adj. R^2		0.388	0.373	0.395	0.402	0.429	0.552	0.555
log L		-18.4	-18.3	-17.1	-16.3	-14.9	-9.98	-9.20

Note: *, **, *** denotes significance on 10, 5, 1% level of significance; t-values given in parentheses.

While in the case of economic success (dependent variable natural log of *REV*), we find a significant decrease of the technological residual from season 1999/00 to 2000/01, there is no significant inter-seasonal change in technology for athletic output; see the last entries of Table 2 (a) and (b). As expected, with regard to, e.g., the merchandising industry, the fan potential variable *UFA* shows a positive, highly significant impact on revenues, while it is estimated insignificantly in the explanation of our scores variable *SCO*. One reason might lie in the truncation of the demand for tickets (especially, for top matches) due to limited capacity of the stadiums. This restriction of capacity puts the impact of (potential) supporters on sporting success into perspective. For both regression exercises reported in Table 2,[10] participation in international competition(s), as reflected by *CHL* and *INT*, respectively, has a

[10] Consisting in specifications S1 to S7, respectively.

decisive, significant impact on output.[11]

Our detailed CD-type production function estimates of choice, generating the best overall fit, are

$$\begin{aligned}\ln(REV) \;=\;& \underset{(3.760)}{1.936} + \underset{(2.813)}{0.545}\ln(PLW) + \underset{(2.168)}{0.271}\ln(COW)\\ &+ \underset{(3.169)}{0.403}\,UFA + \underset{(3.219)}{0.485}\,CHL - \underset{(-2.345)}{0.237}\,S01; \end{aligned} \quad (3)$$

corresponding goodness of fit measures: Adj. R^2: 0.865, logL: −2.555, F-stat.: 45.973, AIC: 0.475, SC: 0.739 and

$$\ln(SCO) = \underset{(1.298)}{0.751} + \underset{(1.891)}{0.376}\ln(PLW) - \underset{(-0.044)}{0.006}\ln(COW) + \underset{(2.875)}{0.455}\,INT; \quad (4)$$

corresponding goodness of fit measures: Adj. R^2: 0.486, logL: −14.201, F-stat.: 12.070, AIC: 1.011, SC: 1.187. For both, (3) and (4), t-values are given in parentheses..

Although the F-Test displayed in Table 1 favors CD as opposed to the more flexible translog specification, the constant, i.e. the natural log of the parameter of technology A (in other words, the Solow residual), as well as the coaching variable COW show no significant impact in estimation (4). Additionally, the players input variable is significant on the ten percentage level only and the overall fit is not really impressing.[12] This leads us to consider also a simple "AK"-model of the form $Y = A(H^p)^\alpha$, where $A = e^{\beta_0+\gamma_1 INT}$, $\alpha = \beta_1$, and PLW proxying the exclusive input factor H^p. For our 1999/00 and 2000/01 pool, the following OLS estimate results

$$\ln(SCO) = \underset{(2.438)}{0.772} + \underset{(2.759)}{0.370}\ln(PLW) + \underset{(2.963)}{0.453}\,INT; \quad (4')$$

corresponding goodness of fit measures: Adj. R^2: 0.502, logL: −14.202, F-stat.: 18.668, AIC: 0.955, SC: 1.087.

[11]Due to collinearity problems, we restricted the regressions to one international participation dummy and based our choice on the respective explanatory power.

[12]One reason for the latter might be that an average production frontier is not the adequate specification. However, this reasoning is only suggestive for an error decomposition (in pure noise and efficiency) and not a significance based test. We will investigate this further using likelihood ratio tests and a test suggested by Coelli (1995) in Section 2.3.

Abstracting from the constant that is significant on the five percentage level, the remaining parameter coefficients of the linearized AK production function are now significant on all conventional levels. Estimates (4) and (4') suggest the interpretation that players and their talent are the decisive input for athletic output. According to (3) and (4') a one percentage increase in *PLW* increases *REV* (*SCO*) by about 0.55 (0.37) %. The participation in the European cups, as reflected by *INT* in (4'), has an impact on the obtained scores *per definitionem* (see Appendix A.1) and potentially through accumulated experience.

The literature on the economics of European top league team sports suggests that the market structure of the leagues is characterized by "rat races" and coordination failures; see, e.g., Szymanski and Smith (1997) for the English Association Football League and Akerlof (1976) in general. Therefore, we would not expect constant or increasing but rather decreasing returns to scale to be at work in the *Bundesliga.* Not surprisingly, our estimates cannot reject the hypothesis of decreasing returns to scale on all conventional levels of significance (the detailed F-Test results are available on request from the authors).

2.3 Maximum Likelihood Estimation of Stochastic Frontiers

The central idea of stochastic frontier analysis to distinguish between shifts in the technological frontier and efficiency, i.e. a movement towards or away from the technological frontier, can best be illustrated by a schematic multi-panel figure, as given at the end of the Appendix. The three panels compare the output of two sample teams, j and k, as a function of human capital input H. Given the same production technology, the higher output of club k in comparison to club j can occur for four possible reasons: First, this can be due to differences in input levels, as displayed in the top panel. Second, the technological base level of production may differ between the two clubs, with the consequence that for the same level of inputs different outputs result; see the second panel. In this case, the technological lead is measured as $A_k - A_j = Y_k - Y_j$. Third, it might be that club j produces less efficiently than club k. In other words, both clubs face the same frontier and the same input level, however, output of team j is lower; see bottom panel. Here, inefficiency is given by the distance $u_j - u_k = Y_k - Y_j$. Finally, differences might be due to a combination of these three plus noise. The isolated Solow residual fails to discriminate between the second and third situation (displayed in the second and third panel), while stochastic frontier methods allow this important distinction.

The most general model in the class of stochastic production frontier specifications is that by Battese and Coelli (1995). It is formulated for panel data with firm effects that are assumed to be distributed as half or truncated normal random variables, whereby these effects may be modelled by some regressors (so called technical efficiency, henceforth TE, effects models), and may be permitted to vary systematically over time.

$$\begin{aligned} y_{it} &= x_{it}\beta + (v_{it} - u_{it}) \qquad \text{for } i = 1, ..., N \text{ and } t = 1, ..., T, \qquad (5) \\ m_{it} &= z_{it}\delta, \text{ where} \end{aligned}$$

- y_{it} denotes the natural log of production of the i-th micro unit in the t-th time period;
- x_{it} is a $k \times 1$ vector consisting of control variables and input quantities (in natural log expression) of the i-th micro-unit in the t-th time period;
- β is a vector of unknown coefficients, over which the likelihood will be maximized;
- v_{it} represent random variables which are assumed to be i.i.d. $N\left(0, \sigma_v^2\right)$ and independent of the
- $u_{it} = u_i e^{-\eta(t-T)}$ non-negative random variables which are assumed (i) to account for technical inefficiency in production and (ii) to be independently distributed as truncations at zero of the $N\left(m_{it}, \sigma_u^2\right)$ distribution; where m_{it} is defined above and
- z_{it} is a $p \times 1$ vector of variables which may influence the efficiency of a micro-economic unit; and

- δ is an $1 \times p$ vector of unknown coefficients, over which the likelihood will be maximized, and for which $\delta_0 = \mu$.

The cross-sectional nature of our dataset allows for specification (5) the case of $T = 1$ (cross-section) and $\eta = 0$ (time-invariant inefficiency) only. Depending on the choice of specifying δ as zero-vector or not, we suppose an error decomposition frontier or a TE effects model, respectively. Imposing for the former $\mu = m_i = m = 0$, we obtain a half-normal specification of the distribution of inefficiencies u_i. With no assumption on μ, the truncated normal specification of Stevenson (1980) results. For $\mu = 0$, it is implicitly assumed that the inefficiency effects u_i are distributed half-normal (HN), whereas the specification of Stevenson (1980) is more general, inasmuch it only supposes a truncated normal (TN) distribution without restriction on its first moment.

Following the parameterization of Battese and Coelli (1995), we use the replacement of σ_v^2 and σ_u^2 with $\sigma^2 = \sigma_v^2 + \sigma_u^2$ and $\rho = \frac{\sigma_u^2}{\sigma_v^2 + \sigma_u^2}$. As a result parameter ρ lies between 0 and 1. This range can be searched to provide a starting value for use in an iterative maximization process like the Davidon-Fletcher-Powell (DFP) algorithm. We consider three distributions of u_i in the course of our estimation strategy: First, the (nested) standard normal (corresponding likelihood maximizing objective: $\max_{\{\beta;u_i\}} L$), second, the HN (corresponding objective: $\max_{\{\beta;\rho\}} L$), and, finally, the TN (corresponding objective: $\max_{\{\beta;\rho;\mu\}} L$) as proposed by Stevenson (1980). For all three distributional assumptions on the inefficiency vector, we also estimate the respective TE specification, where we consider COW_i as m_i-variable (directly impacting on the efficiency of a team). The intuition behind this specification is that especially the respective coach is responsible for the creation of an "efficiency-environment" in the production of athletic and (maybe less so) economic performance. Additionally, we refine the three-step estimation strategy of Battese and Coelli; see Coelli (1992):[13] Accordingly, the three steps are:

[13] Actually, we partly rely on their freeware Fotran77 program FRONTIER 4.1, i.e. the latest follow-up version of FRONTIER 2.0, as outlined in Coelli (1992).

1) Obtain OLS estimates of the production function at stake.

2) Conduct a two-phase grid search of ρ, with β coefficients (excepting β_0) set to the OLS values; where any other parameters (η, μ and δ-vector) are set to zero in the grid search.

3) Use the values selected in the grid search as starting values in an iterative procedure (using the DFP Quasi-Newton method) to obtain the final maximum likelihood (ML) estimates.

After some preliminary estimates and numerical exercises, we call this relatively strict procedure (with regard to the optimality region of the logL value) into question and suggest to replace the second step by:

2') Estimate the model, i.e. maximize the likelihood function over the β- and u_i-vector, under the assumption of the nested standard normal distribution $u_i \sim N^+(0, 1)$. This can be done by approaching the logL value of the OLS estimate in incremental steps, starting from a zero-value.[14] Values of η and the δ-vector are set to zero in this grid search. From the final estimates of residual- and inefficiency-vectors, one obtains a value for ρ. This value, together with the final β-vector estimate, completes the initial values for step 3).

Contrary to the practice of existing related studies (e.g. Dawson *et al.*, 2000, Table 1), we base our choice of model (out of the considered specifications: OLS, HN error decomposition model, TN error decomposition model, HN-TE effects model, and TN-TE effects model) on Likelihood Ratio (LR) tests for

$$H_0 : u_i \geq 0.$$

The latter is a joint equality and inequality hypothesis. Its test statistic is a mixture of χ^2 distributions, where upper and lower bounds for critical values are given in

[14] A code for GAUSS, using the GPE2 package by Lin (2001), is available on request from the authors. It implies a stopping criterion, in the sense that it restricts the incremental grid search to take no longer than 24 hours on a PC with the power of a Pentium IV CPU.

Kodde and Palm (1986). Another indication and test criterion for the presence of technical inefficiency in the data is the third moment of the distribution of the OLS residuals: If $u_i = 0$ for all $i = 1, ..., N$, then the OLS error $\varepsilon_i = v_i$ is symmetric, and the data do not support a technical inefficiency story. However, if $u_i > 0$, then $\varepsilon_i = v_i - u_i$ is negatively skewed, and there is evidence of technical efficiency in the data; see Kumbhakar and Lovell (2000, Section 3.2.2). Since negative skewness occurs when $S_3 = \frac{1}{N}\sum_i^N \left(\frac{\varepsilon_i - \bar{\varepsilon}}{\widehat{\sigma}_\varepsilon}\right) < 0$, a test of the hypothesis that $S_3 \geq 0$ is appropriate. The test by Coelli (1995) avails this feature of the OLS residual vector. Accordingly, under the null of zero skewness of the error terms in equation (1), the following test statistic $\mathcal{K}$ is asymptotically distributed as standard normal

$$\mathcal{K} = \frac{S_3}{\sqrt{\frac{6\left(\widehat{\sigma}_\varepsilon^2\right)}{N}}} \overset{a}{\sim} N(0, 1).$$

In the next section, we report our results, where the choice of model has been based on the above strategy 1), 2'), and 3) and tests on the adequate specification out of the set: OLS, HN error decomposition model, TN error decomposition model, HN-TE effects model, and TN-TE effects model.

3. Results

3.1 Success on the Pitch: Sporting Efficiency

As argued above, the residuals of the OLS estimate reported in (4') are suggestive for a stochastic frontier model to the extent that they are negatively skewed, as reflected in a third moment $S_3 = -0.106$. The implied test statistic by Coelli (1995), $\mathcal{K} = -0.713$, rejects the OLS model on all levels of significance. However, from the remaining four specifications considered, it is only the TN error decomposition (TN-ED) model that passes the LR test against OLS. The corresponding LR test statistic equals 3.719 and rejects OLS in favor of the TN-ED model on the five percentage level; see Kodde and Palm (1986). The final ML estimate is

$$\ln(SCO) = 1.360^* + 0.401^* \ln(PLW) + 0.385^* INT + \varepsilon, \quad \text{where} \tag{6}$$

$$\varepsilon_i \in \varepsilon \text{ and } \varepsilon_i = v_i - u_i \text{ for } i = 1, ..., 36;$$

$$v_i \sim N\left(0, \sigma_v^2\right) \text{ and } u_i \sim N^+\left(\widehat{\mu}, \sigma_u^2\right);$$

$$\widehat{\rho} = \frac{\sigma_u^2}{\sigma_v^2 + \sigma_u^2} = 0.999^*, \text{ and } \widehat{\mu} = 0.574^*;$$

corresponding logL: -12.305; '*' denotes significant estimate on all conventional levels of significance.

The efficiency transforms $EFF_i = \exp(-u_i)$ of the inefficiency parameters u_i are displayed in Table 3 below. Again, it is noteworthy that we abstract from *COW* as well in our stochastic frontier model (6) due to the fact that wages of coaches neither play a significant role in the determination of athletic output nor in the creation of an efficient environment (TE effects specification) according to our estimates. Not surprisingly, *INT* is again estimated strongly significant as teams can *ceteris paribus* attain more *SCO*-points if qualified internationally.

Table 3 provides the ranking of the 36 observations based on the estimated efficiency-vector for the 21 clubs at stake. SC Freiburg wins the race with an estimated technical efficiency of 0.9993 in season 2000/01, being closely followed by FC Bayern München with its 1999/00 performance and FC Schalke 04 in 2000/01. At the bottom of the table, we find MSV Duisburg in 1999/00 with an estimated efficiency of less than one fourth of SC Freiburg. How might this be explained? The case of Freiburg (00/01) is quite well known: The team from the South-Western corner of Germany had the third smallest budget in terms of players, in both years, but finished with the seventh highest number of *SCO*-points (8.86) without participating in an international European competition. This is a good example of efficiency in our specified framework. FC Bayern München (99/00) made the third highest investment in terms of players' salaries in 1999/00 but also transformed them into an outstanding amount of 23 *SCO*-points by winning the domestic league and cup competition, as well as making it to the semi-final of the Champions League.

Table 3. *SCO* Efficiency ranking based on TN error decomposition model

RANK	CLUB	SEASON	TECHN. EFFICIENCY
1	SC FREIBURG	00/01	0.9993^{+}
2	FC BAYERN MÜNCHEN	99/00	0.9992^{+}
3	FC SCHALKE 04	00/01	0.9992^{+}
4	SV WERDER BREMEN	99/00	0.8794^{+}
5	FC BAYERN MÜNCHEN	00/01	0.8583^{+}
6	SC FREIBURG	99/00	0.8059^{+}
7	HANSA ROSTOCK	99/00	0.7768^{+}
8	VFB STUTTGART	99/00	0.6871^{+}
9	BAYER 04 LEVERKUSEN	99/00	0.6368^{+}
10	SSV ULM	99/00	0.6266^{+}
11	VFL WOLFSBURG	00/01	0.6253^{+}
12	1. FC KAISERSLAUTERN	00/01	0.6228^{+}
13	FC ENERGIE COTTBUS	00/01	0.6090^{+}
14	HANSA ROSTOCK	00/01	0.5825^{+}
15	VFB STUTTGART	00/01	0.5691^{+}
16	VFL WOLFSBURG	99/00	0.5608^{-}
17	SV WERDER BREMEN	00/01	0.5374^{-}
18	HAMBURGER SV	99/00	0.5326^{-}
19	HERTHA BSC BERLIN	99/00	0.5192^{-}
20	BORUSSIA DORTMUND	00/01	0.5181^{-}
21	VFL BOCHUM	00/01	0.4803^{-}
22	TSV 1860 MÜNCHEN	99/00	0.4733^{-}
23	HERTHA BSC BERLIN	00/01	0.4677^{-}
24	SPVGG UNTERHACHING	00/01	0.4535^{-}
25	TSV 1860 MÜNCHEN	00/01	0.4522^{-}
26	1. FC KÖLN	00/01	0.4434^{-}
27	BAYER 04 LEVERKUSEN	00/01	0.4324^{-}
28	SPVGG UNTERHACHING	99/00	0.4239^{-}
29	1. FC KAISERSLAUTERN	99/00	0.4126^{-}
30	ARMINIA BIELEFELD	99/00	0.4087^{-}
31	EINTRACHT FRANKFURT	99/00	0.3855^{-}
32	BORUSSIA DORTMUND	99/00	0.3497^{-}
33	EINTRACHT FRANKFURT	00/01	0.3032^{-}
34	HAMBURGER SV	00/01	0.2982^{-}
35	FC SCHALKE 04	99/00	0.2910^{-}
36	MSV DUISBURG	99/00	0.2161^{-}

Note: Mean efficiency: 0.5621; '+' ('−') indicates above (below) average efficiency.

FC Schalke 04 shows the third highest level of efficiency due to its 2000/01 domestic performances, i.e. without playing internationally. They attained the second most *SCO*-points in that season, winning the national cup and historically losing the *Bundesliga* to FC Bayern München in the extra time of the season. The story was quite different for FC Schalke 04 the year before: Investing the third highest *PLW* of the season, they collected only 3.81 *SCO*-points ending last but one in Table 3. They are underperformed only by MSV Duisburg, the club that achieved an even less athletic output (i.e. 22 league points, knock-out in the second round of the national cup) than their relatively low budget (i.e. 5.88 million EUR) indicated.

Looking at the 15 clubs that participated in the *Bundesliga* in both seasons, it is interesting to assess intertemporal performance. FC Bayern München and SC Freiburg performed very efficiently in both years. Overall winner SC Freiburg is ranked sixth with their 1999/00 performance. FC Bayern München takes second and fifth place. Ordering clubs by the sum of their subsequent ranking positions for an *ad hoc* intertemporal assessment, results in the pattern of Table 4. Eintracht Frankfurt, obviously, shows the most persistently weak performance. Its efficiency estimates are the fourth (2000/01) and the sixth lowest (1999/00) for the 36 points of observation. The table also highlights that FC Schalke 04, by far, displays the highest volatility in performance when comparing the two seasons. As mentioned above, after a poor 1999/00 season this club overperformed in 2000/01 without significantly increasing investment in players' salaries.

Table 4. *Bundesliga*-participants in both seasons by *EFF*-Ranks

CLUB	*EFF*-Rank in 1999/00	*EFF*-Rank in 2000/01	*EFF*-Rank (sum) both seasons
SC FREIBURG (1)	6	1	7
FC BAYERN MÜNCHEN	2	5	7
WERDER BREMEN (3)	4	15	19
HANSA ROSTOCK	7	12	19
VFB STUTTGART (5)	12	13	21
VFL WOLFSBURG (6)	14	10	24
BAYER 04 LEVERKUSEN (7)	9	23	32
FC SCHALKE 04 (8)	30	3	33
1. FC KAISERSLAUTERN (9)	25	11	36
HERTHA BSC BERLIN (10)	17	20	37
TSV 1860 MÜNCHEN (11)	19	22	41
BORUSSIA DORTMUND (12)	27	18	45
HAMBURGER SV	16	29	45
SPVGG UNTERHACHING	24	21	45
EINTRACHT FRANKFURT (15)	26	28	54

Note: In parantheses respective rank according to the sum of *EFF*-ranks is given.

3.2 Success off the Pitch: Economic Efficiency.

Contrary to (4'), OLS estimate (3) neither shows a weak fit nor any indication in favor of an ED or TE effects model. Although none of the considered stochastic frontier models passes the adequate LR test, we succeed in marginally improving the likelihood by decomposing the error term.

Table 5. OLS and Stochastic Frontier estimates for dependent variable ln(*REV*)

Model	*CONST*	ln(*PLW*)	ln(*COW*)	*UFA*	*CHL*	*S01*	ρ	logL
OLS	1.936*** (3.760)	0.545*** (2.813)	0.271** (2.168)	0.403*** (3.169)	0.485*** (3.219)	-.237** (-2.34)	—	-2.555
HSN	3.510*** (6.861)	0.513*** (4.143)	0.177 (0.918)	0.777*** (6.119)	0.445*** (2.960)	-.153 (-1.51)	—	-2.438
HN	1.947*** (3.491)	0.544*** (3.132)	0.274** (2.425)	0.404*** (3.402)	0.484*** (3.604)	-.240** (-2.59)	0.001	-2.465

Note: *, **, *** denotes significance on 10, 5, 1% level of significance; t-values given in parentheses.

In analogy to equation (6) above, Table (5) displays our estimates with best fit. As argued above, we used a half normal ED model to obtain initial values for the DFP algorithm in the estimation of the HD-ED model.

As described in Section 2.2, we not only find that there is a significant coherence between wages of players and coaches and the overall economic output of a team, but also learn that there is a technological downward shift from season 1999/00 to 2000/01. This means, in terms of our supposed production function, that more wages had to be invested to reach the same REV level than in the year before. Here the "rat race" for the limited amount of output comes back into play. *PLW*, e.g., climbed by 23% on average between 1999/00 and 2000/01, *COW* by 26%. One of the components of revenues that cannot be extended for all league members is the cash flow from broadcasting rights that now has been directly linked to the sporting performance of the clubs.

The significance of our *UFA* variable neither comes as a surprise. Nine out of the top ten clubs in the *UFA* poll played in the German top league in 1999/00 and 2000/01. Having many fans can usually be attributed to some tradition of success: Each of the top five clubs either won the domestic league or the national cup competition at least once in the seasons 1996/97-2001/02. Obviously, title wins in the past and/or the present generate a large fan community.[15] Having many fans implies large attendances, a higher-than-average merchandising potential, an attractiveness for sponsors, etc. and, therefore, higher revenues. The *CHL* dummy is, again not surprisingly, the most significant variable of the $\ln(REV)$ OLS-equation (3). In 2000/01 FC Bayern München generated more than 50 million EUR (total revenue: 173 million EUR) solely by their winning of the Champions League. For first round drop-outs in the Champions League, German teams are still consoled with 13-15 million EUR due to the financially strong German TV-market in comparison to other European (Champions League participating) countries.

[15] A different story might hold for Hansa Rostock being the only *Bundesliga* team from the former GDR for a long time. They benefit from a regional monopoly and a strong sympathy throughout the *Neue Bundesländer*.

Table 6 (a). *REV* Efficiencies (1999/00): OLS and error decomposition models

CLUB	OLS RK	model	HN RK	ED model 0.9986+...[a]	HSN RK	ED model
VFB STUTTGART	1	0.524	1	$4702e^{-5}$	1	0.845
SSV ULM	2	0.317	3	$4380e^{-5}$	7	0.683
EINTRACHT FRANKFURT	3	0.316	2	$4383e^{-5}$	8	0.680
SV WERDER BREMEN	4	0.251	4	$4281e^{-5}$	2	0.786
ARMINIA BIELEFELD	5	0.159	5	$4130e^{-5}$	5	0.708
SC FREIBURG	6	0.141	6	$4102e^{-5}$	13	0.424
VFL WOLFSBURG	7	0.113	7	$4065e^{-5}$	9	0.662
MSV DUISBURG	8	0.064	8	$3986e^{-5}$	4	0.714
FC BAYERN MÜNCHEN	9	0.046	9	$3952e^{-5}$	3	0.730
HANSA ROSTOCK	10	0.030	10	$3933e^{-5}$	16	0.324
BORUSSIA DORTMUND	11	-.067	11	$3776e^{-5}$	14	0.417
BAYER 04 LEVERKUSEN	12	-.083	12	$3755e^{-5}$	15	0.389
SPVGG UNTERHACHING	13	-.127	13	$3685e^{-5}$	6	0.701
TSV 1860 MÜNCHEN	14	-.325	14	$3372e^{-5}$	11	0.459
1. FC KAISERSLAUTERN	15	-.328	15	$3371e^{-5}$	18	0.223
HAMBURGER SV	16	-.332	16	$3353e^{-5}$	17	0.309
HERTHA BSC BERLIN	17	-.339	17	$3352e^{-5}$	12	0.442
FC SCHALKE 04	18	-.362	18	$3318e^{-5}$	10	0.513

Note: ED - error decomposition model; HSN - half standard normal; RK - rank.

[a] for HN-ED model: efficiency estimate equals row value + 0.9986.

In the following economic efficiencies are discussed for those teams that showed a robust 'top' or 'flop' ranking pattern. Being part of the respective upper or lower quartile (top-4 / flop-4) of the ranking for all three models, is considered a robust result. As can be seen from Table 6 (a) above, VfB Stuttgart clearly dominates all three rankings of *REV* efficiency in 1999/00. An explanation needs to be based on all the relevant variables: In the respective season, VfB Stuttgart invested the league-average amount of money into *PLW* and *COW*;[16] while, in terms of *REV*, it ended fifth. The decisive factor for reaching the top, in terms of efficiency value estimates,

[16]In detail, this corresponds to rank nine (eight) for *PLW* (*COW*).

therefore, seems to be that the club attained this relatively high *REV* with average wages. Furthermore, this stands despite the fact that its team neither participated in the Champions League in 1999/00 nor does it belong to the better loved half of the league (*UFA* fan dummy = 0).

Surprisingly, Stuttgart ended at the very bottom in the succeeding season; see Table 6 (b). The club increased wages for its staff above the average but reached a rather low (adjusted) *REV* of 14.7 million EUR. This might to some degree be explained by its weak performance in the national league that season (ending 15th). SV Werder Bremen also turns out to be robustly top4-efficient (as regards *REV*) in 1999/00. The club generated the eight highest *REV* with below-average *PLW* and, remarkably, by paying their coach the second lowest salary. Being one of the nine most popular clubs (according to our *UFA* variable), seems to have no affect on its efficiency. The argument goes the other way around for 1. FC Kaiserslautern and Hamburger SV in 1999/00: Both clubs seem unable to transform their high *COW* (second and fifth highest) as well as their popularity, in terms of *UFA*, into corresponding *REV* results. In regard to the top quartiles of *REV* efficiency for season 2000/01, FC Schalke 04 is the only club to operate consistently well. In this case, the below average *COW* and the absence in the Champions League seem to outweigh the fourth-highest *PLW*. Hansa Rostock is the second club apart from VfB Stuttgart that stands out for its exceptionally weak performance in this season. Low *PLW* and the second lowest *COW* (0.22 million EUR) obviously do not justify the third lowest *REV* of 11.53 million EUR, as reflected by its estimated efficiency term. In this case, the message from the underlying OLS model is that the club from the coast of the Baltic Sea could have made more out of its popularity in the East German region (*UFA* fan dummy = 1).

Table 6 (b). *REV* Efficiencies (2000/0!): OLS and error decomposition models

CLUB	OLS RK	model	TN RK	ED. model 0.9986+...[a]	HSN RK	ED model
BORUSSIA DORTMUND	1	0.593	1	$4809e^{-5}$	6	0.594
FC BAYERN MÜNCHEN	2	0.393	2	$4506e^{-5}$	8	0.550
FC SCHALKE 04	3	0.236	3	$4249e^{-5}$	1	0.772
1. FC KÖLN	4	0.219	4	$4214e^{-5}$	12	0.467
SV WERDER BREMEN	5	0.151	5	$4129e^{-5}$	16	0.359
1. FC KAISERSLAUTERN	6	0.114	6	$4063e^{-5}$	7	0.551
BAYER 04 LEVERKUSEN	7	0.072	7	$3996e^{-5}$	11	0.505
EINTRACHT FRANKFURT	8	0.001	8	$3889e^{-5}$	15	0.359
HERTHA BSC BERLIN	9	-.008	9	$3873e^{-5}$	14	0.364
HAMBURGER SV	10	-.022	11	$3846e^{-5}$	10	0.515
FC ENERGIE COTTBUS	11	-.024	10	$3852e^{-5}$	2	0.698
SC FREIBURG	12	-.086	12	$3752e^{-5}$	13	0.446
TSV 1860 MÜNCHEN	13	-.086	13	$3748e^{-5}$	4	0.672
VFL BOCHUM	14	-.167	14	$3621e^{-5}$	9	0.533
SPVGG UNTERHACHING	15	-.177	15	$3606e^{-5}$	3	0.687
VFL WOLFSBURG	16	-.339	16	$3349e^{-5}$	5	0.633
HANSA ROSTOCK	17	-.355	17	$3316e^{-5}$	18	0.248
VFB STUTTGART	18	-.512	18	$3077e^{-5}$	17	0.328

Note: ED - error decomposition model; HSN - half standard normal; RK - rank.

[a] for TN-ED model: efficiency estimate equals row value + 0.9986.

4. Conclusion

The present study contributes to the existing literature on managerial efficiency in professional team sports. In a stochastic frontier framework we empirically assess the performance of German *Bundesliga*-clubs in the two seasons 1999/00 and 2000/01. In contrast to existing studies applying DEA, we are able to make significance based statements and to consider stochastic deviations from the efficiency frontier. Furthermore, we choose our production technology specifications on a series of tests and refine the estimation procedure proposed by Battese and Coelli (1995).

The player talent constitution of teams is found to be of paramount importance for success on and off the pitch. Surprisingly, paying a high salary to the coach seems to have no significant impact on the athletic output. A robust pattern of technical efficiency over the subsequent seasons is found for athletic performance, while the estimates based on economic output highlight the instability of the German soccer industry. In both cases only a few clubs show persistently a low or high level of efficiency.

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Appendix

Appendix A.1

The *SCO* variable: Aggregating performance in up to three competitions

In most studies of team or coaching efficiency in professional soccer performance is measured by the achievement only in the national league competition.[17] Since the teams know by the end of each season for which national and international competitions in the following season they are qualified, they also base their pre-seasonal investment on this knowledge. Not only more competitions mean more matches and therefore require a larger squad they also mean more income.

In the present study, we are the first to construct a variable "score" (*SCO*) that takes into account the performances in all four competitions of relevance for German teams. Apart from the league competition all 18 *Bundesliga*-clubs are automatically qualified for the national cup (i.e. the DFB-Cup)[18], too. Internationally, German clubs can qualify for the UEFA-Cup[19] or for the UEFA Champions League (UEFA-CL)[20]. Therefore a German club could play 57 matches at maximum in one season (34 matches in the league, six in the DFB-Cup, and 17 matches in the UEFA-CL). Even though not necessarily every club management in Germany might agree, there is a broad consensus about the relative importance of the four potential competitions: Winning the UEFA Champions League is ranked the highest achievement in European professional soccer. The national league (*Bundesliga*) is ranked second due to the fact that the German league is considered a rather high-level competition by European standards. The UEFA-Cup title is an international achievement but most clubs would prefer winning the national league *ceteris paribus*. The DFB-Cup certainly receives

[17] One exception being Gerrard (2001) who also considers the domestic (English) cup competitions.

[18] DFB-Cup in 1999-2001: six one-leg knock-out rounds with the "1st Round" being the round in which the 18 top league clubs enter the competition.

[19] UEFA-Cup in 1999-2001: seven knock-out rounds with two legs, final is one match; for qualification rounds and the UI-cup no points are attributed.

[20] UEFA Champions League in 1999-2001: two group stages, two-leg knock-outs from the quarter final, final is one match, qualification rounds are not considered.

the least weight in Germany, especially, since it generates the least additional money and due to the possibility of winning the title after lucky draws and only six matches.

We take the above ranking as a basis for our scoring-system. Winning the UEFA-CL is ascribed ten, the national league nine, the UEFA-Cup eight, and finally the DFB-Cup seven *SCO*-points. Economic implications of the different performances do not play a role in the construction of the *SCO*-variable. It is only the success on the pitch that is being reflected in *SCO*-points. We, therefore, clearly discriminate between the marginal impact of reaching a final and actually winning it. The reason is that title-wins are what success on the pitch is standing for and less semi-final qualifications etc. Accordingly, the runner-up in the UEFA-CL (UEFA-Cup, DFB-Cup) receives eight (six, five) *SCO*-points, the two semi-final losers seven (five, four) *SCO*-points. This system also ensures that the ordinal ranking of the three cup competitions stays the same whichever group stage. Table A.1 shows the *SCO*-points that could be achieved in the 1999-2001 seasons for the eight (DFB-Cup: seven) possible outcomes in those three competitions. Clubs that ended up third in the first group stage of the UEFA-CL dropped out of the UEFA-CL but entered the third round of the UEFA-Cup. They therefore could still reach a minimum of two *SCO*-points from the international cup competitions. In 1999/00 (2000/01) Germany had four (three) teams starting in the UEFA-CL and three (five) teams in the UEFA-Cup.

Table A.1. Receivable *SCO*-points in 1999/00 and 2000/01

for DFB-/UEFA-Cup	DFB-Cup	UEFA-Cup	UEFA-CL	for UEFA-CL
Winner	7	8	10	Winner
Runner-Up	5	6	8	Runner-Up
Semi-Final-K.O.	4	5	7	Semi-Final-K.O.
Quarter-Final-K.O.	3	4	6	Quarter-Final-K.O.
1/8-Final-K.O.	2	3	4	3rd pl./2nd group stage
3rd-Round-K.O.	does not exist	2	3	4th pl./2nd group stage
2nd-Round-K.O.	1	1	↖	3rd pl./1st group stage
1st-Round-K.O.	0	0	0	4th pl./2nd group stage

Note: Arrow indicates drop-out in UEFA-CL 3rd pl./1st group stage continues in UEFA-Cup 3rd round.

In the national league competition the teams play 34 matches against each other and collect three points for a win, one point for a draw. We decided to transform the points in the league rather than the final league position into our *SCO*-system such that success on the pitch is mapped more exactly. As in the other competitions the runner-up stays two *SCO*-points short of the champion, i.e. they collect seven *SCO*-points. Teams finishing third or lower receive *SCO*-points determined by the following equation:

$$SCO_i\,|_{\text{league}} = 9\left(\frac{\text{league-points}_i}{\text{league-points}_{Ch}}\right) - 2, \tag{A.1}$$

where league position $i = 3, ..., 18$ and subscript Ch denoting champion.

By (A.1) the league performance is benchmarked to the performance of the champion with the restriction that no other team can collect more than seven *SCO*-points. Since we are not interested in the future economic implications of league positions, there are no *SCO*-premiums or -discounts for European cup qualifications or relegations. Table A.2 shows how many *SCO*-points the top league clubs collected from the competitions in total and through the national league in 1999/00 and 2000/01, respectively. Due to the fact that we are only looking at one-year *SCO*-performances of top league clubs, cup participations of second division (*Zweite Bundesliga*) clubs are not accounted for. In one season a club can reach a maximum of 26 *SCO*-points. In 1999/00, for example, FC Bayern München is assigned an outstanding 23 *SCO*-points by winning the national league as well as cup and reaching the semi-final in the UEFA-CL. At the bottom end, MSV Duisburg only received 1.71 *SCO*-points in 1999/00, finishing last in the league with 22 points (FC Bayern München: 73) and dropping out of the national cup in the second round.

Table A.2. *SCO*-points total and from league for seasons 1999/00 and 2000/01[21]

CLUB	*SCO* (total) in 1999/00	*SCO* (total) in 2000/01	*SCO* (league) in 1999/00	*SCO* (league) in 2000/01
HERTHA BSC BERLIN	9.16	9.00	4.16	6.00
ARMINIA BIELEFELD	3.70	N.P.	1.70	N.P.
VFL BOCHUM	N.P.	4.86	N.P.	1.86
SV WERDER BREMEN	12.79	8.57	3.79	5.57
FC ENERGIE COTTBUS	N.P.	4.57	N.P.	3.57
BORUSSIA DORTMUND	7.93	8.29	2.93	6.29
MSV DUISBURG	1.71	N.P.	0.71	N.P.
EINTRACHT FRANKFURT	3.81	3.00	2.81	3.00
SC FREIBURG	5.93	8.86	2.93	5.86
HAMBURGER SV	6.27	5.86	5.27	3.86
1. FC KAISERSLAUTERN	7.16	11.14	4.16	5.14
1. FC KÖLN	N.P.	4.57	N.P.	4.57
BAYER 04 LEVERKUSEN	11.00	9.14	7.00	6.14
TSV 1860 MÜNCHEN	5.53	8.29	4.53	4.29
FC BAYERN MÜNCHEN	23.00	20.00	9.00	9.00
HANSA ROSTOCK	6.68	5.14	2.68	4.14
FC SCHALKE 04	3.81	14.00	2.81	7.00
VFB STUTTGART	6.92	10.43	3.92	3.43
SSV ULM	4.32	N.P.	2.32	N.P.
SPVGG UNTERHACHING	3.42	4.00	3.42	3.00
VFL WOLFSBURG	8.04	6.71	4.04	4.71

Note: Clubs in alphabetical order of brand-constituting city, region or district.

[21] N.P. denotes team not participating in the *Erste Bundesliga* in the respective season.

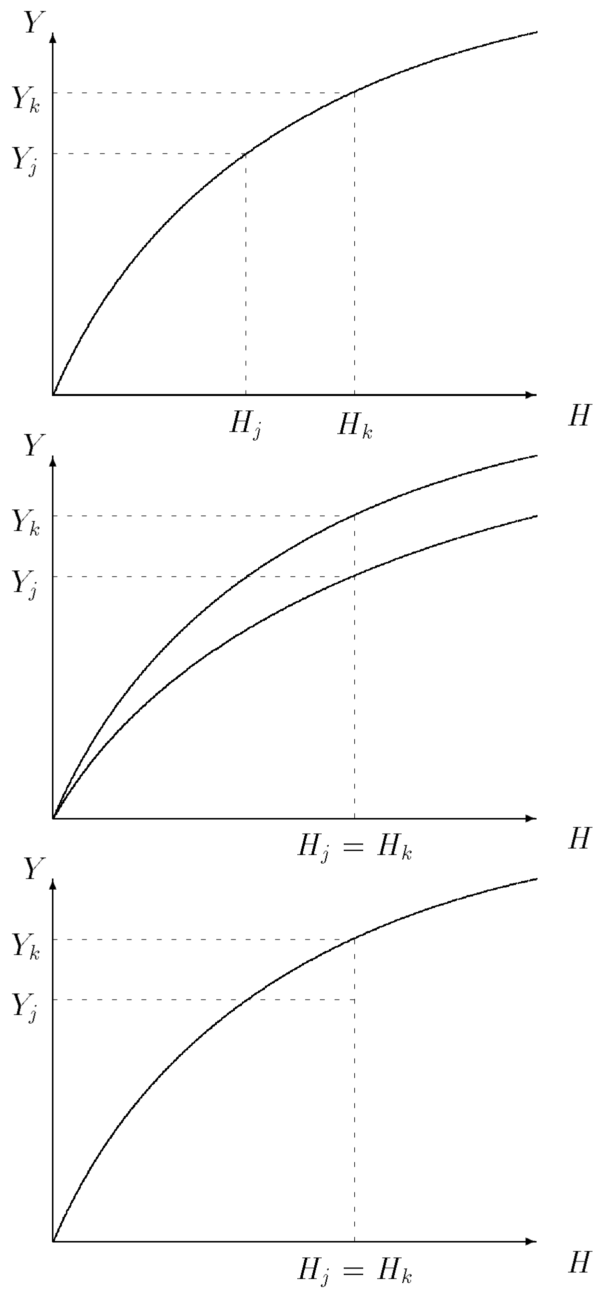
Appendix A.2

Descriptive statistics of non-dummy variables

Table A.3. Descriptive statistics of central (non-dummy) variables

	Mean	Median	Max.	Min.	Std. Dev.	Skewness	Kurtosis
SCO [a.]	7.708	6.816	23.00	1.712	4.428	1.703	6.378
REV [million EUR]	37.49	25.03	157.2	8.751	35.32	1.983	6.489
PLW p.a. [million EUR]	14.87	12.55	33.20	4.090	8.328	0.853	2.832
COW p.a. [million EUR]	0.676	0.534	1.841	0.135	0.497	1.097	3.251

Note: a. For detail see Appendix A.1.



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