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THE IMPACT OF MANAGERIAL QUALITY ON ORGANIZATIONAL PERFORMANCE: EVIDENCE FROM GERMAN SOCCER

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Abstract

Although a considerable literature exists on the determinants of managerial compensation, much of it focussing on the role of incentives, there is much less known about the impact of managerial remuneration and quality upon attainment of organizational goals. In this paper we apply two distinct econometric methods to panel data on head coach quality and team performance in Germany's premier soccer league. We find that, given a particular amount of spending on players relative to the rest of the league, a team that hires a better quality head coach can expect to achieve improved performance.

Keywords: professional soccer, stochastic frontier analysis, managerial quality, organizational performance

JEL-Code: J44, L83, M50

1. Introduction

There is now an extensive literature on determination of managerial and CEO pay, much of it driven by analysis of the classic principal-agent problem in modern firms. Prendergast (1999) surveys a variety of research on the general issue of personnel and organizational responses to alternative incentive mechanisms. In particular, Conyon and Murphy (2000) examine the relative sensitivities of CEO pay to company performance in the US and UK. Schwalbach and Graßhoff (1997) and Kraft and Niederprüm (1999a; 1999b) perform comparable analyses using data from German companies. Bertrand and Mullainathan (2001) address the question of the extent to which relative performance evaluation determines CEO salaries. The position of CEO salaries within company wage structures has also been considered. For instance, Conyon *et al.* (2001) test hypotheses from tournament theory using British company data, showing that company wage structure is indeed highly convex across top echelons of management. The relationship between different forms of corporate governance and executive pay has received attention in a number of papers (e.g. Conyon *et al.* (2001) and Hallock (2002)).

This research typically concerns the impact of company performance on managerial salary, traced through theoretical impacts of incentive mechanisms on managerial effort. The reverse relationship between managerial quality and organizational performance has received far less attention. This is not surprising. The data requirements needed to properly separate out substitutability and complementarity amongst the host of inputs to firm outputs in complex, modern organizations are usually too great to overcome and the risk of omitted variable bias is bound to be high. Employer-based surveys have questions that are often too broad to permit a focus on detailed technological and behavioural relationships between organizational inputs and outputs. Case studies using personnel records in particular companies are helpful but results do not necessarily generalise.

As Kahn (2000) has persuasively argued, the sports industry is a useful sector within which to test interesting hypotheses in the area of personnel economics. In professional team sports, organizational goals and outcomes are much clearer than in most other sectors. Teams usually wish to maximise sporting performance given available resources with which to acquire playing and managerial talent. Increased sporting performance usually translates

into higher revenues and profits for team owners. In North American team sports in particular, there exists a plethora of individual performance and salary data often publicly available on the internet. In Europe, where soccer is easily the dominant team sport, such data have more restricted availability.

A general principle that can be applied to most sports leagues is that teams that pay higher total salaries for their playing rosters relative to the league average will, on average, achieve better performance. Performance can be measured by percentage of games won or points achieved. In European soccer, owners and fans are likely to respond to position in the league rankings since particular positions have further implications such as qualification to higher level European competition. Empirical support for the general upward sloping relationship between relative team salaries and team performance has been found, using a number of performance metrics and across a variety of sports leagues, in North America and Europe, by Szymanski and Kuypers (1999), Szymanski (2000; 2003), Simmons and Forrest (2004) and Kahane (forthcoming).

Even in the sports sector, studies showing the impact of managerial quality on organizational performance are sparse and limited in coverage. Some literature focuses on coaching efficiency of sports teams as part of a more general treatment of team efficiency (e.g. Porter and Scully (1982), Hadley *et al.* (2000), Dawson *et al.* (2000), Hautsch *et al.* (2001), Poulsen (2000), Audas *et al.* (2002), Salomo and Teichmann (2002), Koning (2003) and Kahn (2004)). This literature lacks direct evidence on coaching remuneration. Again, this is largely due to lack of available data. In the case of English soccer, the league studied by Dawson *et al.*, the only wage data available for use as an input to team production was total wage bill for the entire staff of the club. As the authors acknowledge, this total wage bill measure conflates influences of player and coaching salary on team performance. Even the pioneering study of managerial quality effects in Major League Baseball by Kahn (1993) was hampered by only having a single season's data for managerial salary (this also applies to Kern and Süssmuth (2003)). Generally, coaching salaries in North American sports are publicised far less than individual player salaries.

Our focus in this paper is on European soccer, specifically the top tier of German soccer (henceforth Bundesliga 1) for which head coach salary data are publicly available. Within

European soccer, the head coach takes primary responsibility for training and selection of playing personnel and all on-field team decisions including playing strategy and tactics. Credit for team success and, conversely, blame for failure will usually reside with the head coach, often accompanied by intense media scrutiny. Normally, the head coach in European soccer is not directly involved in issues relating to player contracts. However, he will usually be closely involved in recommending which players to hire and fire and which players to be rewarded in contract extensions and renewals.

The global reach of European soccer teams and mobility of labour mean that the market for head coach talent can be thought of as competitive. The supply of head coach talent is best considered as upward sloping in salary-talent space. Head coaches arrive to teams through various routes but it is conventional to be a former professional player[1] and possibly to have served as an assistant coach prior to appointment as head coach. A recent trend in European soccer, following the internationalization of playing talent, is the increased appearance of foreign-born head coaches in the major leagues of England, Germany, Italy and Spain.

In such a highly competitive market, where managerial skills are easily transferable, we can expect that salaries of coaches will closely approximate marginal revenue products. In a global soccer market, monopsony power becomes irrelevant. Therefore, given an upward sloping supply curve in salary-talent space, managerial salary should be a good proxy for managerial talent. Given expenditure on team wage bills, increased spending on head coach salaries ought to imply acquisition of a higher level of managerial talent. However, the league is a competition which sorts teams into ranks (league standings); in order to make progress in terms of league position teams need to acquire increased playing and managerial talent *relative* to league norms. Increased expenditure on managerial talent, relative to league average should translate, on average, into improved team performance. It is not obvious that this hypothesis will be supported by evidence. If managerial talent is homogeneous and pay dispersion across head coaches is very low then the impact of managerial pay on team performance will necessarily be small.

The central question addressed in this paper using German soccer as a particular case is: does variation in managerial quality affect organizational performance? It is possible that the *sole* influence on team performance is spending on player wage bill relative to the league average (Simmons and Forrest, 2004). Then head coaches are just ciphers translating pre-existing player talent into on-field success or failure. Likewise, in many modern organizations, a CEO could simply be a figurehead with no active defining role. Folklore from within European soccer suggest this is not the case: head coaches matter in terms of organizational and motivational ability. The most successful head coach in our sample is Ottmar Hitzfeld who obtained considerable success at Borussia Dortmund and Bayern Muenchen, leading these teams to a total of six domestic championship titles and each to a Champions' League trophy. Not surprisingly Hitzfeld had the highest relative salary in each season during his most recent spell with Bayern Muenchen. If a significant role can be found for head coach quality in determination of soccer team performance then one may conjecture that there is potential for impact of executive quality on organizational performance to be revealed in other industry sectors.

The remainder of the paper proceeds as follows. In section 2, we review our data and estimation methods. We follow two complementary econometric procedures: stochastic frontier estimation and fixed effects panel data estimation. These apply a points ratio measure and league rankings, respectively. Section 3 displays our stochastic frontier results while Section 4 switches attention to findings from fixed effects model. Section 5 concludes.

2. Data and Estimation Methods

Our data come from a Sunday newspaper (*Die Welt*) that publishes team wage bills and head coach salaries immediately before the start of a season. These data span 22 seasons from the inception of Bundesliga 1 in 1981/82 through to 2002/03. Supplementary data on team playing records were obtained from *Kicker* soccer magazine. With the single exception of 1991/92, Bundesliga 1 contains 18 teams[2]. Since 1992/93, at the end of each season the

1 However, it is certainly not essential to have been a high-profile star as a player in order to be a successful head coach. Currently, some of Europe's most successful head coaches were not successful players e.g. Mourinho at Chelsea who was only an amateur player.

2 In 1991/92, following unification of East and West Germany, the top two teams from the first division of the former German Democratic republic were admitted to Bundesliga 1 and the number of teams was

three lowest placed teams are demoted and replaced by the three highest placed teams from the second tier, Bundesliga 2[3]. One particularly notable structural change in German soccer is the change in number of points awarded for a win from two to three installed in 1995/96 largely as an incentive to encourage more attacking, entertaining play.

These data give us an unbalanced panel of 398 team-season observations featuring 39 teams. Six of these (Bayern Muenchen, Werder Bremen, Borussia Dortmund, Hamburger Sportverein, Bayer Leverkusen and VfB Stuttgart) have appeared in Bundesliga 1 over the entire sample period; five clubs (Blau-Weiss Berlin, Darmstadt 98, VfB Leipzig, Kickers Offenbach and SSV Ulm) were relegated after just one season.

Some descriptive information on team wage bills and head coach salaries is shown in Figures 1 and 2. These are kernel density plots which show skewed distributions of team wage bills and head coach salaries even when scaled by season league averages. However, the extent of skewness in team wage bills is actually less than in other European soccer leagues (Simmons and Forrest, 2004). Dispersion and skewness are both features of the kernel density plot of head coach salaries suggesting that managerial talent is heterogeneous and that there is some potential for differences in head coach relative salary to affect team performance.

Stochastic Frontier Estimation

Following Battese and Coelli (1995), a log-linear Cobb-Douglas production function for a set of firms indexed by i over a number of periods t can be represented as:

$$Y_{it} = x_{it}\beta + (v_{it} - u_{it}) \qquad i = 1,\ldots..N;\ t = 1,\ldots.T \qquad (1)$$

where Y_{it} is the natural log of output , x_{it} is a vector of inputs, also in logs and β is a coefficient vector to be estimated[4]. The remainder of the equation is an error term comprising

temporarily increased to 20. At the end of the 1991/92 season, four teams were relegated to Bundesliga 2 while only two were promoted, restoring the traditional league size of 18.

3 Prior to 1991/92, a two game playoff between the team placed 16th in Bundesliga 1 and the team placed 3rd in Bundesliga 2 settled, by aggregate score, one of the places in Bundesliga 1 for the subsequent season.

4 We also estimate a more flexible translog functional form.

two parts. v_{it} is a random error term with standard iid properties. u_{it} is a non-negative random error term assumed to follow a normal distribution truncated at zero; this last term captures potential inefficiencies in production. If these are found to be zero in estimation then we can revert to standard econometric procedures to estimate a production function with panel data. But if these inefficiencies are found to be significantly different from zero then production function estimates that assume efficiency could well be biased.

The estimated technical inefficiency terms could themselves be correlated with a further set of explanatory variables. This possibility was explored by Battese and Coelli (1995) and a study from professional sports that follows this two-stage approach is Kahane (forthcoming). Assume that u_{it} has a distribution truncated at zero and given by $\sim N(m_{it}, \sigma_u^2)$. Mean inefficiency can be modelled as a function of specific firm-level influences by :

$$m_{it} = z_{it}\delta + w_{it} \qquad (2)$$

where z_{it} is a vector of firm-specific influences on inefficiency in firm i in period t and δ is another vector of coefficients to be estimated. The error term w_{it} is assumed to be $\sim N(0, \sigma_w^2)$ truncated at $-z_{it}\delta$ for consistency with the assumption that u_{it} is non-negative and truncated at zero.

In our case, 'output' is given by log of end-of-season points as a ratio of maximum possible, *LOG REL POINTS*. Included in x_{it} are measures of relative team wage bill, *LOG REL WAGEBILL* and relative head coach salary, *LOG REL SALARY*, each scaled by league averages in any given season. Since the change in points regime has the effect of lowering mean points ratio (from 0.5 with two points per win to 0.45 for three points per win) we also include a dummy variable *THREE POINTS* to indicate seasons covered by the new points regime.

In the second stage of the model, we have five covariates. Two measures reflecting managerial ability that might conceivably impact on technical inefficiency are coach experience (number of seasons experience as head coach in the Bundesliga, *COACH EXP*) and coaching win-loss records (proportion of possible points earned as head coach, *COACH WIN*). Each of these measures would be predicted to reduce technical efficiency as they are in-

creased. This is largely due to selection and sorting; the least efficient managers are likely to be identified through their poor performance, given the playing resources available to them, and consequently fired[5].

Teams that are promoted may, even allowing for lower wage bills, struggle to compete effectively in the top tier of soccer as they adjust to new playing surroundings, new teams and different playing styles and strategies at the higher level. We might predict that promoted teams face a learning curve as they adjust to the higher level of soccer. Learning effects are incorporated by the variable *SPELL* which is the number of seasons in Bundesliga 1 that have accrued since last promotion. Therefore a team like Hamburger Sportverein which has never been demoted has a value of *SPELL* that is equal to number of seasons that the Bundesliga 1 has been in existence. A team such as SSV Ulm which only has one season in the Bundesliga 1 has a spell value of one.

Managerial turnover in European soccer is rather frequent. In Germany, single-case head coach dismissals occur in a total of 118 out of 398 team-season observations; there are another 23 cases of two or three dismissals[6]. A team that fires its head coach during the season is denoted by the dummy variable *DISMISS 1* while the less common occurrence of two or more head coach departures within a season is captured by *DISMISS 2*. The underlying reasons for coach dismissal are not explored here, although poor team performance is the usual proximate cause. All we seek to capture is the unsettling impact of head coach departure on team organization and morale through team inefficiencies. We predict that head coach dismissals will be associated with increased team inefficiency specifically as a current season impact[7].

5 We should stress that it is technical inefficiency rather than absolute level of performance which is the key variable in the second stage of our model. Absolute ability should be reflected in the head coach's salary. A head coach can be associated with a low level of performance yet be highly technically efficient according to our econometric evidence. Conversely, a head coach could be associated with a high level of performance yet be technically inefficient. In the former case, a coach is highly likely to be fired due to director and fan (mis-)perception of incompetence, In the latter case, the head coach might receive an unduly high level of praise. Such anomalies have surfaced in some stochastic frontier models of European soccer team performance (e.g. Dawson *et al.* 2000).

6 It should be stressed that these are dismissals and not voluntary quits.

7 In dismissing a head coach during the season a team could have two views on the likely gains. One short-term view is that the change in head coach is a quick fix which can quickly restore life to an ailing team. Game-level empirical evidence from European soccer suggests only limited short-term improvement in match results (e.g. Bruinshoofd and ter Weel, 2003, on Dutch soccer). Alternatively, teams may take a longer view and assess that a new head coach can bring better performance in the future even though current performance may be disappointing. A team may be judged to be already condemned to relegation

Equations (1) and (2) can be estimated using the maximum likelihood method proposed by Battese and Coelli (1993) and made available in Coelli's (1996) computer program *FRONTIER 4.1*. The maximised log-likelihood function gives estimates of σ^2 and γ where $\sigma^2 = \sigma_v^2 + \sigma_u^2$ and $\gamma = \sigma_u/(\sigma_v^2 + \sigma_u^2)$. The γ parameter is particularly important as it shows the proportion of sum of the two error variances that is accounted by technical inefficiencies. If this parameter is not significantly different from zero then we cannot reject the null hypothesis of zero technical inefficiencies and we would revert to standard panel data econometric procedures to estimate our team production function.

Fixed effects estimation with endogenous coach salary

One problem with our stochastic frontier model lies with our choice of team output measure, points attained divided by maximum possible. Although league points and league standings will be highly correlated, a particular points ratio can translate into different league positions in different seasons. Winning the Bundesliga title will entail a different number of points to be achieved in any season depending on how close the competition for the title becomes. Likewise, retention of Bundesliga 1 status (i.e. avoiding relegation) will also entail a different number of points again contingent on number of teams involved in a relegation struggle in any season. Club directors and fans are more likely to respond to league standings and what these deliver in terms of team achievement than points ratios.

To model league standings we propose the logistic transformation of position, given by *LOG ODDS POSITION* set equal to – log (position/(n+1 – position)) where n is total size of Bundesliga 1, currently 18[8]. The logistic form implies that a movement between adjacent league positions carries greater weight, and higher implied effort to achieve, higher up the league rankings.

Currently in Germany, particular positions imply particular categories of team achievement. The highest is winning the Bundesliga 1 title. However, this also ensures qualification to

due to poor performance under a dismissed head coach and fortunes may be judged to improve eventually under a new appointment (see Höffler and Sliwka 2003). Borland and Lye (1996) argue, with evidence from Australian Rules football, that *two* teams could significantly improve performance by swapping head coaches as the switch could generate a better match for each team, given particular team and coach characteristics.

the more prestigious European Cup and its successor, the UEFA Champions' League. The UEFA Champions' League currently includes the top three teams from Bundesliga 1. Entry to the Champions' League secures, as a minimum, enhanced gate, broadcasting and sponsorship revenues and potential for lucrative prize money if German clubs progress in the competition[9]. Lower down, another group of teams qualifies for the UEFA Cup. This is still a prestigious tournament but with lower levels of prize money and less allure than the Champions' League[10]. Normally, the Bundesliga sends four teams (those placed 4th to 6th plus domestic Cup winner) to the UEFA Cup. Teams which do not qualify for European competition will aim to avoid relegation, which is the fate of the bottom three teams.

Teams that spend more on team wage bills are also likely to spend more on head coach salaries. In our sample, the correlation coefficient between relative wage bill and relative head coach salary is 0.62. In order to identify the impact of head coach, we instrument relative head coach salary using *COACH EXP*, *COACH WIN* and *SPELL*. The first stage of our instrumental variables model with team fixed effects is:

$$\textit{Log relative coach salary} = a_0 + a_1 * \textit{Log relative wage bill} + a_2 * \textit{Coach points ratio} + a_3 * \textit{Coach experience} + a_4 * \textit{Spell} + a_5 * \textit{Dismiss 1} + a_6 * \textit{Dismiss 2} + \text{team fixed effects} + e_t \quad (3)$$

The fitted values from this equation *Predicted relative coach salary* are then entered into the second stage where:

$$\textit{Log odds position} = b_0 + b_1 * \textit{Predicted relative coach salary} + b_2 * \textit{Log relative wage bill} + b_3 * \textit{Dismiss 1} + b_4 * \textit{Dismiss 2} + \text{team fixed effects} + \varepsilon_t \quad (4)$$

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8 The standard metric for North American sports team performance is percentage of games won. Log odds of league position is applied in some empirical work on European soccer leagues (e.g. Szymanski (2000)).

9 Recently the Champions' League trophy was won by Borussia Dortmund (1996/97) and Bayern Muenchen (2000/01).

10 The Champions' League begins as a set of leagues of four teams from which the top two proceed to a knock-out phase played over one home and one away game and settled, sequentially aggregate score or highest number of away goals scored if the aggregate goals are level or penalty shoot-out if both aggregate and away goals are each level. The ruling giving higher implicit weighting to away goals was introduced to provide greater incentive to away sides to pursue less defensive play. Teams that are eliminated from their Champions' league groups are still entitled to compete in the UEFA Cup by entering part way through the competition. Hence, some teams can actually enter both competitions in the same season.

3. Stochastic Frontier Estimates

Table 2 reports stochastic frontier estimates. Our dependent variable is log points ratio and the production function has a Cobb-Douglas form[11]. The coefficient γ is positive and significant at the one per cent level. Hence team inefficiencies are important in explaining variations in points ratios and we therefore reject estimation of a standard production frontier in favour of a stochastic frontier model. The elasticities of points ratio with respect to relative wage bill and relative coach salary are 0.211 and 0.045, significant at one per cent and five per cent levels respectively. The higher elasticity for player wage bill is not surprising: no matter how good the motivation and tactical awareness of the coach, it is the players who perform on the pitch. Their relative importance in team production is greater than for the head coach.

Our production function exhibits diminishing returns to both relative wage bill and relative coach salary and decreasing returns to scale in team and head coach talent, as proxied by salaries. According to these estimates, acquiring better managerial talent by raising relative head coach salary by 100 per cent, e.g. taking relative coach salary from one to two, can raise total points from a mean of 49 to a new total of 51. This may seem rather small but we should stress that it is achieved with no change in total playing talent, as measured by relative wage bill, and with other teams also striving to obtain improved managerial quality. As we shall see below, such a difference in points may turn out to be crucial for achieving particular club objectives such as qualification for European competitions or avoiding relegation.

Acquiring a head coach with a better record, measured in terms of career points ratio achieved, has the further beneficial effect of reducing team inefficiency. This is shown in the sign and value of the parameter δ_2. This is negative and significant at the one per cent level suggesting that a higher coach career points ratio reduces technical inefficiency. In contrast, the insignificant δ_1 parameter shows that for given coach career points ratio, having greater managerial experience is not associated with reduced inefficiency. Quite reasonably, experience of winning dominates experience *per se* as the key managerial character-

11 The more flexible translog form was tested and rejected due to jointly insignificant coefficients on squared and cross-product terms.

istic which helps improve technical efficiency and move the team towards its potential output.

The other δ parameters are all statistically significant at the one per cent level. The significantly negative δ_3 parameter shows that a team that has enjoyed a longer continuous spell in Bundesliga 1 than a rival will, *ceteris paribus*, enjoy reduced inefficiency. This possibly reflects a cumulative learning experience for clubs with prolonged tenure in the top division of German soccer. In contrast, recently promoted clubs have smaller values of *SPELL* and hence greater inefficiency scores.

A team that loses one head coach in a season will suffer increased technical inefficiency with a bigger effect if the club goes on to lose two or even three head coaches. Given the turbulence that usually surrounds a head coach departure this is to be expected, although the departure may itself reflect some underlying problems such as loss of customer (fan) support, financial failure and lack of co-operation between team-mates. This does not imply that firing head coaches is irrational as teams may believe that long-term gains (by acquiring a better head coach) will outweigh short-term losses of efficiency.

The stochastic frontier estimates show the relative importance of head coach quality and reveal an important role for head coach quality in moving teams closer to their production frontiers. However, points ratios do not translate easily into particular team objectives and use of league rankings, through log odds of position, can help give further insights.

4. Two Stage Least Squares Estimates

Table 3 reports our two stage least squares estimates of equations (3) and (4)[12]. In the relative coach salary equation, the coefficient on coach experience is significant at one per cent while the impact of coach career points ratio on relative salary is not significantly different from zero. We also find that teams which have longer current tenure in the German top division spend more on head coach salaries relative to the divisional average; an increase in

12 Estimations using Generalised Two Stage Least Squares, following Balestra and Varadharajan-Krishmakumar (1987). See Baltagi (2001) for a general discussion of panel data models with endogenous regressors. We applied our instruments to relative wage bill as the endogenous variable but coefficients on both rela-

spell is associated with higher relative coach salary. These results reflect the selection and sorting mechanism in the coaches' labour market, identified in team sports by Borland and Lye (1996) in the market for head coaches in Australian Rules football using duration analysis. More generally, this is an example of assortative matching identified in the personnel economic literature (Prescott, 2003).

In our context, the best head coaches will be the most experienced since these have passed the test of quality by survival. They will be attracted to the most durable Bundesliga teams (Bayern Muenchen or Borussia Dortmund, for example) which have the greatest potential for winning domestic and European titles and which have longer current tenure in the Bundesliga. In order to attract these valuable head coaches, teams must pay more than the league average. Coaches that have high career points ratios for their teams tend to be more likely to survive as head coaches in Bundesliga 1. Those coaches with poorer points records will be fired. The career points effect is then subsumed under the effect of experience and this accounts for the lack of significance of the coefficent on coach career points ratio.

In the second stage of the model, both relative wage bill and predicted head coach salary influence log odds of position, with coefficients significant at one per cent. Teams with higher predicted relative head coach salary or higher relative wage bill are expected to achieve higher league positions. In contrast, teams that lose one or more head coaches in a season will obtain lower league positions. We should stress that our two-stage model imposes the plausible restriction that an increase in relative team wage bill cannot raise league position on its own; any increase in relative wage bill must be accompanied by higher relative coach salary. This restriction, which is supported by the data, captures the essential technical complementarity of head coach and player abilities. Coaching and player talent are then Edgeworth complements as defined by two key characteristics. First, an increase in use of player talent raises the marginal valuation of coaching talent. Second, more player talent is optimally accompanied by increased head coach talent.

Table 4 shows some simulations of changes in relative head coach salary and relative wage bill required to achieve particular targets within the league. These simulations are based on

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tive coach salary and predicted relative wage bill were insignificant at the 5 percent level. This reinforces our choice of relative coach salary as endogenous to our instruments.

our estimates in Table 3. Holding relative wage bill constant, the first column shows the extra head coach relative salary required to win the league title, beginning with second place. This turns out to be a dramatic increase taking the relative head coach salary to a value that is only just within sample range. Not surprisingly, a team can better achieve this target by investing in both player talent and head coach talent. Lower level achievements can, however, be obtained by improving relative spending on the head coach, holding player relative wage bill constant. The second column, first row, shows the increase in relative wage bill that would be needed, according to our model, to win the title and the final column shows the implied change in relative head coach salary that would accompany such a change. In the case of moving from second to first, the required increase in relative wage bill is again large. The required increments in relative head coach salary and relative wage bill are of course much greater at the top end of the league because of the logit transformation of position adopted here[13].

Further down the league, we see less dramatic changes in relative head coach salary and relative wage bill that could bring about entry into either of the European tournaments or avoidance of relegation. For example, an increase in relative wage bill from 1.06 to 1.34, combined with small increase in relative head coach salary from 1.08 to 1.11, is sufficient to gain UEFA Cup entry, starting from seventh place. To avoid relegation, a team could find a better quality head coach by raising its relative spending from 0.77 to 1.35 and keeping spending on relative wage bill constant at 0.71. Alternatively, the club could invest in the playing squad by raising player expenditures to just beneath the league average (0.98) and raising head coach quality by increasing relative spending from 0.77 to 0.88, still below the league average. Essentially, to improve league performance the club owners must decide on a combination of extra spending on managerial talent and extra spending on the playing squad.

5. Conclusion

Our modelling exercise in this paper produces several key results. First, the stochastic frontier estimates showed that extra spending on managerial talent vested in a head coach has

13 This simulation abstracts from the negative impact on league position that would occur if the team were to fire an existing coach prior to hiring the coach of better quality. As such, the simulation is best consid-

the impact of pushing the team production frontier outward in points ratio-relative wage bill space. The elasticity of this relative head coach salary effect is much smaller, however, than the elasticity of relative player wage bill. If a more successful coach can be hired, then we find that the team's technical efficiency is improved. Better managerial quality, proxied here by coach career points ratio, can move a German soccer team closer to its production frontier. We attribute this result to a sorting and selection mechanism. Those coaches with best winning records have the greatest potential to extract improved performance out of a given pool of playing talent, thereby improving efficiency. This result is worth investigating further in other contexts. The literature on CEO salaries would benefit from consideration of appropriate CEO career records so as to examine of the impact of changes in CEO quality on movements towards production frontiers.

We also found that longevity in the top tier of the Bundesliga produced greater technical efficiency, a result that we associate with learning experience. The Bundesliga is a highly competitive structure with guaranteed entry each season and it is clear that, in this context, established teams cannot and do not settle for comfort and inefficiency. Further, coach dismissals are associated with reduced technical efficiency although presumably this can be offset by hiring a new coach who has a better winning record than his predecessor.

In our instrumental variables fixed effects model we identified technical complementarity of playing and managerial inputs. Relative head coach salary was successfully instrumented by coach career experience. Implicitly, coaches with greater experience are paid higher salaries, a reasonable result reflecting acquisition of more human capital through learning.

Our instrumental variables model shows that, generally, investment in player talent through higher relative wage bill needs to be accompanied by some investment in coaching talent if teams are to progress up the league. Sometimes, though, holding relative spending on players constant and hiring a better quality coach can be a plausible route to success although most likely not in terms of winning the league title.

The best head coaches arrive and stay at the top clubs in German soccer through a process of matching and sorting. We defer an explicit analysis of matching and selection models in

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ered as a prediction of changes in equilibrium talent levels for players and coach.

sports to further research but our results would seem to be consistent with assortative matching in the market for head coaches. Given an upward sloping supply curve for managerial talent, more ambitious clubs offer higher managerial salaries in order to hire a more talented head coach. However, the competitive structure of the league is such that the extra spending must be *relative* to the rest of the league and not just absolute. If a club succeeds in hiring and retaining a better quality head coach and is then able to back this investment up with extra relative spending on player talent then the club can improve its performance.

From both stochastic frontier modelling and instrumental variables estimation, we find that relative spending on playing talent and on head coach talent combine effectively to reduce technical efficiency and improve league performance. Players and head coaches need each other and we find strong evidence from both our modelling approaches of complementarity between player and head coach inputs to team success. The best teams hire the best head coaches and the best playing talent and relative expenditures are good proxy measures for talent in our sports league setting. The literature on personnel economics would benefit from further examination of such complementarities in other settings.

Figure 1:
Kernel Density Estimate of Relative Wage Bill

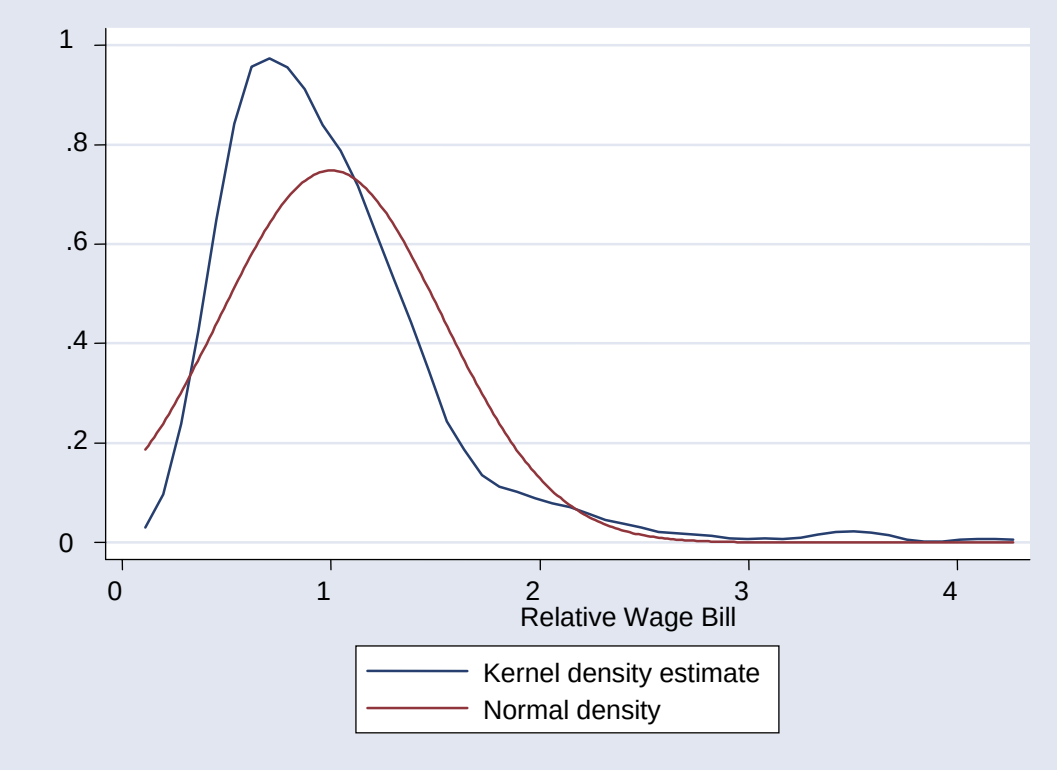

Figure 2:
Kernel Density Estimate of Relative Head Coach Salary

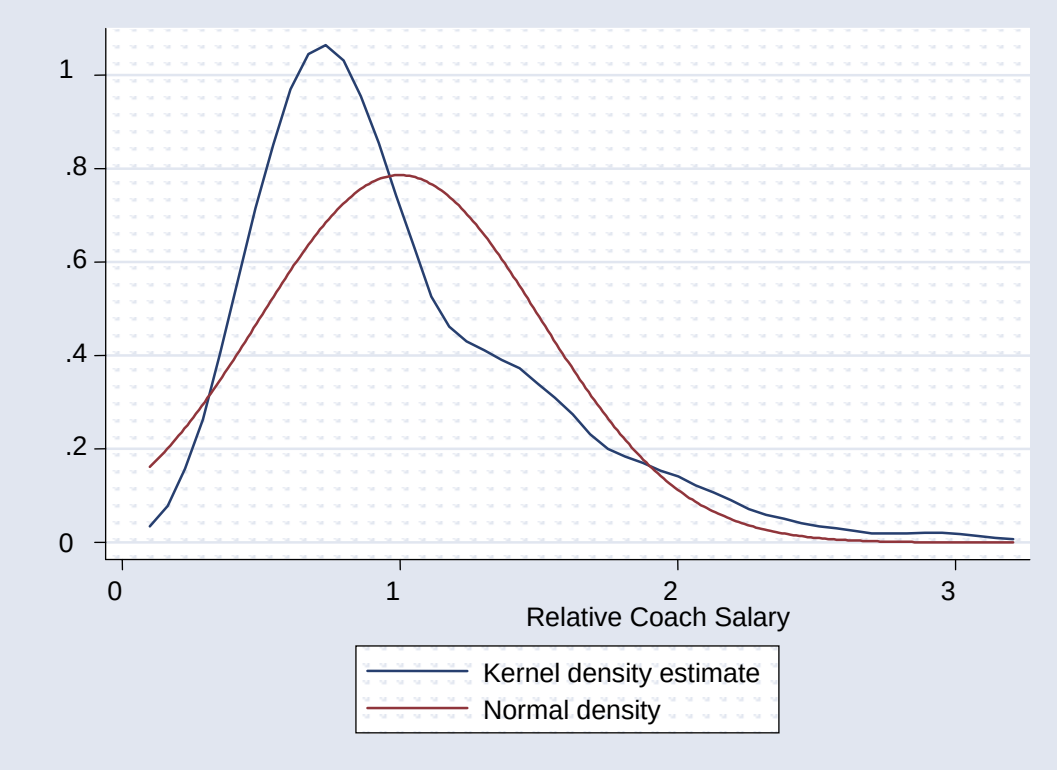

Table 1:
Descriptive Statistics for Bundesliga Teams: 1981/82 to 2002/03
(n = 398)

	Mean	*Standard Deviation*	*Minimum*	*Maximum*
Team inputs				
Relative wage bill	1.000	0.533	0.230	4.147
Relative coach salary	1.000	0.507	0.226	3.079
Head coach measures				
Coach career points ratio	0.435	0.215	0	0.850
Coach career experience	4.37	4.82	0	27
Team measures				
Spell	7.17	6.06	1	22
Dismiss 1	0.296	0.457	0	1
Dismiss 2	0.058	0.234	0	1

Table 2:
Stochastic Frontier Estimation of a Cobb-Douglas Production Function for Bundesliga 1

Dependent variable is log points ratio.

	Parameter	***Coefficient (t statistic)***
Team Inputs		
Log relative wage bill	β_1	0.211
		(7.76)
Log relative coach salary	β_2	0.045
		(1.99)
Three points	β_3	-0.105
		(5.45)
Intercept	β_0	-0.399
		(4.93)
Head Coach Measures		
Career Bundesliga games coached	δ_1	-0.116
		(1.94)
Career points ratio	δ_2	-0.004
		(1.18)
Team Level		
Spell	δ_3	-0.009
		(3.30)
Dismiss 1	δ_4	0.212
		(5.45)
Dismiss 2	δ_5	0.433
		(7.62)
Inefficiency model intercept	δ_0	0.306
		(2.75)
Variance parameters		
Total error variance	σ^2	0.034
		(7.38)
Proportion of error variance due to technical inefficiencies	γ	0.764
		(4.49)
Mean technical efficiency		0.759
Log likelihood		153.7

Table 3:
Instrumental Variables Fixed Effects Estimation

Dependent variable is log odds of position

Variable	***Relative coach salary***	***Log odds position***
Relative coach salary		0.682
		(2.27)
Relative wage bill	0.356	0.455
	(7.76)	(2.51)
Dismiss 1	-0.054	-0.946
	(1.50)	(8.24)
Dismiss 2	-0.012	-1.868
	(0.16)	(8.02)
Spell	0.0094	
	(2.86)	
Coach experience	0.036	
	(8.63)	
Coach points ratio	0.109	
	(1.27)	
Constant	0.389	-0.749
	(6.34)	(2.97)
Proportion of error variance due to fixed effects	0.29	0.41
Correlation between fixed effects and regressors	0.27	0.39
F statistic for significance of fixed effects	4.00	2.49
R^2 *(within)*	0.34	0.31
R^2 *(overall)*	0.54	0.47

Table 4:
Changes in Relative Head Coach Salary and Relative Wage Bill Required to Raise League Position

Change in Position	Required Change in Relative Salary	Required Change in Relative Wage Bill	Implied Change in Relative Coach Salary
2 to 1 (Win League Title)	1.48 to 3.31	1.47 to 2.65	1.48 to 1.95
4 to 3 (Qualify for Champions' League)	1.06 to 1.64	1.33 to 1.83	1.06 to 1.22
7 to 6 (Qualify for UEFA Cup)	1.08 to 1.48	1.06 to 1.34	1.08 to 1.11
16 to 15 (Avoid Relegation)	0.77 to 1.35	0.71 to 0.98	0.77 to 0.88

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