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Specific Human Capital as a Source of Superior Team Performance**

Abstract

We empirically investigate the performance effect of team-specific human capital in highly interactive teams. Based on the tenets of the resource-based view of the firm and on the ideas of typical learning functions, we hypothesize that team members' shared experience in working together have a positive effect on team performance, but at diminishing rates. When we hold constant a team's stock of general human capital and other potential drivers, we find support for this prediction. We also discuss the implications concerning investment decisions into human capital as well as the transferability of our findings to other contexts.

JEL-Classification: C12, C23, M54.

Keywords: Human Capital; Learning; Resouce-Based View of the Firm; Team Performance.

1 Introduction

In this paper, we empirically investigate the question of whether a team's shared experience, i.e., its stock of team-specific human capital, as an intangible and unobservable resource that has a positive effect on team output. Scholars who quantify specific human capital use measures such as tenure (see, e.g., Sandell and Shapiro (1980); Berman, Down, and Hill (2002)) or qualitative survey data about various organizational factors (see, e.g., Hansen and Wernerfelt (1989)). In contrast, we measure team-specific human capital by the actual number of deployments for the current team in a competitive context. We argue that our proxy measure better reflects the members' cumulative experience in cooperating than does pure tenure. Unlike other papers, we distinguish between the separate effects of specific and general human capital on performance. As our proxy measure for the team's stock of general human capital, we use estimates of the team members' market potential.

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These estimates are primarily driven by general components of human capital. Using panel data of 25 different soccer teams in the German *Bundesliga*, with a total of 3,672 match observations, our empirical analysis is based on a larger sample than that used by any other related study. Thus, we believe that our paper can make a unique contribution to the empirical literature relating specific human capital to team performance.

2 Conceptual Framework And Hypotheses

2.1 Is Specific Human Capital Valuable?

In the following section, we first examine whether team-specific human capital qualifies as a critical resource for achieving a sustained competitive advantage. According to the resource-based view, a critical resource must add value to the firm, it must be rare, it must be inimitable and it must not be substitutable by an alternative resource (Barney (1991)). Here, we discuss the four criteria individually.

Specific human capital describes the skills, experiences, and knowledge that are useful only to a single employer or industry, but general human capital, such as literacy or basic computer skills, is freely transferable because it is useful to several employers (Becker 1964)). Williamson (1985) notes that specific human capital generates a quasi-rent. Generally, a quasi-rent refers to the difference between the productivity in the current deployment and the second-best alternative. Thus, the degree of specificity corresponds to the scale of the quasi-rent. In the case of general human capital, there is no quasi-rent. According to Williamson (1975), the main reason why specific human capital is lost when the employer changes is that its components are idiosyncratic. Both Becker (1962) and Williamson (1975) emphasize that idiosyncrasies are acquired in a continuous learning-by-doing process and, thus, depend on the duration of the transaction relationship.

Sandell and Shapiro (1980) investigate the impact that young women's ex ante preferences for future labor force attachment have on their human capital accumulation and pay. The authors use years of labor market experience as a proxy variable for general human capital and years of tenure with the current employer as a proxy variable for specific human capital. They find that continuing gender differentials in job tenure and in cumulative work experience explain a large part of the gender differential in earnings, and that women's relative earnings increase when their work experience and job tenure increase. Sandell and Shapiro do not directly investigate productivity effects, but the wage growth among young women is at least indicative of a productivity increase.

A few empirical studies attempt to measurably isolate the productivity effect of specific human. Hansen and Wernerfelt (1989) investigate the relative explanatory power of economic and organizational factors in explaining interfirm differences in profit rates. As a proxy measure for firm-specific resources, they utilize a questionnaire (Survey of Organizations, SOO) that captures many dimensions of organizational factors, such as decision-making practices, goal emphasis, and job design, as well as the characteristics of communication flow, the emphasis on human resources, and the organization of

work. Their findings show that industry explains 19% of the variance in profit rates, but that organizational characteristics, including specific human capital, are about twice as important.

In their study on the impact of shared experience on the performance of basketball teams, Berman, Down, and Hill (2002) use a weighted average of prior seasons for the current team as a proxy variable for shared experience. They find that shared experience is a highly significant determinant of team performance. In a team context in which each member's specific human capital is only valuable to the current team, the utility of this asset depends on the stability of the workforce, i.e., the team members' tenure.

Based on these arguments and findings, we argue that specific human capital can reasonably be assumed to be a valuable resource.

2.2 Is Specific Human Capital Rare?

Generally, we agree with Wright, McMahan, and McWilliams (1994), who argue that if output depends to at least some extent on human capital, which allows for variance in individual contributions, then these skills should be normally distributed in the population. Hence, high-quality human resources should be rare. Moreover, the development of both general and specific human capital requires investment in training, but only general human capital is available through the market mechanism. In other words, there is by definition no supply of specific human capital beyond the internal labor market, although there should be demand because specific human capital adds value to the firm. These properties support the description of specific human capital as rare.

2.3 Can Specific Human Capital Be Imitated?

The specific human capital generated in a continuous learning-by-doing-process is unlikely to be imitated because to a large extent it is implicit in the process (Doeringer and Piore (1971); Franck (1995)). Through cumulative experience, certain processes become so internalized that their successful execution happens unconsciously and cannot be verbally explained. The implicit character of specific human capital makes it all but impossible to formalize (Lippman and Rumelt (1982)) and thus impedes imitation.

This idea applies to individual employees and even more to highly interactive teams that are performing a common task. A team's stock of specific human capital consists of a socially complex interaction of implicit and noncodifiable skills. In the course of a mutual learning-by-doing process, the team improves its ability to synchronize individual actions according to each member's responsibility. Hence, we follow Weick and Robert's (1993) concept of the collective mind representing the specific human capital that is collectively held by a group of individuals. This asset is diffused among the team members, each of whom has access to only a part of the overall stock of the team-specific human capital. Thus, it is impossible to dissect the complexity of interactions in order to isolate individual

contributions to team output (Wright, McMahan, and McWilliams (1994)). The fact that in team production, the total output typically exceeds the sum of its members' inputs further complicates the problem of identifying critical resources (Alchian and Demsetz (1972)). Even in team production processes that are openly observable to externals, there is causal ambiguity concerning the reasons for superior performance (Reed and DeFillippi (1990); Powell, Lovallo, and Caringal (2006)).

At the extreme, luring away the entire workforce of a competitor seems to be the only way to circumvent both the causal ambiguity and the immobility of specific human capital, but this approach neglects that a team's effectiveness may be tightly coupled to other resources of the firm (Wright, McMahan, and McWilliams (1994)). A team's effectiveness may further depend on relationships with other teams or on unique historical circumstances (Alchian and Demsetz (1972)). Thus, specific human capital is safe from imitation. In all likelihood, competitors are neither able to identify the source of competitive advantage, nor able to copy the critical components of the specific human capital and the circumstances under which these work.

However, Porter (1985) argues that "… barriers to imitation are never insurmountable." If other teams could identify the source of competitive advantage and imitate it, then the barriers to imitation would still be contingent on the cost of imitation. In the case of specific human capital, imitation is costly, especially in terms of time. Therefore, scholars of the resource-based view propose that high performance can be sustained for at least some time

2.4 Can Specific Human Capital Be Substituted?

Specific human capital by itself cannot give rise to sustained competitive advantage if other resources can offset performance increments attributable to specific human capital. To elaborate on the question of substitutability, we emphasize that the only resources that can substitute for specific human capital are, in their own right, valuable, rare, inimitable, and non-substitutable. For example, a team's additional investment in its stock of general human capital or its application of a superior technology can erode the benefits of a competitor team's superior stock of specific human capital. However, neither factor is capable of consistently substituting for specific human capital because these resources are available for purchase in the marketplace. Their free imitability prevents them from acting as a source of sustained competitive advantage (Wright, McMahan, and McWilliams (1994)). Hence, a team's stock of specific human capital is unlikely to be substitutable because the requirements for a substitutive resource are difficult to meet.

In sum, our line of reasoning leads us to assume a positive relation between a team's stock of team-specific human capital and team performance.

Hypothesis 1: *There is a positive relation between a team's stock of team-specific human capital and team performance.*

2.5 Learning Effects

The learning curve is a well-known phenomenon. As an organization gains experience, organizational performance improves at a decreasing rate. Scholars have researched learning curves extensively, and managers have often used learning curves for planning purposes (Argote (1999)).

When members of a team accumulate specific human capital in a constant learning process that facilitates their interaction, several theoretical arguments suggest that these learning effects are subject to diminishing returns. Over the last 50 years, the phenomenon of diminishing returns as a consequence of typical learning effects has also been documented empirically (see Yelle (1979), and Dutton and Thomas (1984), for reviews). These authors' main argument is that there is a limit to the returns of team-specific human capital and that this limit is determined by the production technology. Team cooperation cannot infinitely improve as the stock of team-specific human capital increases. Hence, there are typical learning-curve effects. A newly composed team initially has great potential for learning-based improvements, but the attainment of such improvements corresponds to a reduction of the remaining learning potential. In line with theoretical arguments and empirical findings, we assume that the relation between a team's stock of team-specific human capital and team performance is concave, not linear, in shape.

Hypothesis 2: *The relation between team-specific human capital and team performance is subject to diminishing returns. The positive performance effects of team-specific human capital will decline as shared experience grows.*

2.6 Heterogeneity Of Team-Specific Human Capital

Although a team's total stock of team-specific human capital is central to our theoretical predictions, the composition of team members in terms of their individual working experience with the team may also matter. One viewpoint is that the team's composition requires continuity for mutual learning processes to improve interaction and to induce positive returns, especially if the successful accomplishment of complex team tasks requires complementary skills. In performing conjunctive tasks, one member's lack of certain skills cannot be compensated by other team members' superior skills (Kremer (1993)). This argument suggests that a team should be homogeneous in terms of their members' tenure. The heterogeneity of specific human capital within a team may also create a distancing of relationships between team members that impairs the exchange of information and thus the quality of interaction (Ancona and Caldwell (1992)). In some instances, heterogeneity may create distrust, because widely dissimilar group members may have different vocabularies, paradigms, and even objectives.

Another viewpoint is that homogeneity may be counterproductive if there are too many status-seeking members, because in such a case the team's (implicit) hierarchy is insufficiently differentiated (Overbeck, Correll, and Park (2005); Groysberg, Polzer, and Elfenbein (2007)). Managers can find it fruitful to expose team members to new perspectives.

From this viewpoint, the most successful teams may consist of a combination of experienced members who possess a lot of team-specific human capital and new members who supply fresh ideas. Also, the introduction of new team members may circumvent free-riding tendencies and productively increase competition within the team (see, e.g., Alchian and Demsetz (1972); Holmström (1982)).

As with these contradictory perspectives, the empirical findings have been mixed. Some studies show a negative relation between tenure heterogeneity and different performance measures, such as innovation (O'Reilly and Flatt (1989)), adaptive change in a sample of electronics firms (O'Reilly, Snyder, and Boothe (1993)), and informal communication within the team (Smith et al. (1994)). Berman, Down, and Hill (2002) find no significant relation between tenure heterogeneity and team performance in professional basketball. Using data from the airline industry, Hambrick, Cho, and Chen (1996) find evidence of a positive link between tenure heterogeneity and two measures of performance. Despite the inconsistent theoretical predictions and inconclusive empirical results, we expect heterogeneity in team-specific human capital to be harmful, given the high degree of team members' interactivity in the production process of a soccer match. Hence, we assume that the heterogeneity of team-specific human capital has a negative effect on team performance.

Hypothesis 3: *There is a negative relation between the heterogeneity of team-specific human capital and team performance.*

3 Methods

To test our hypotheses, we study a large panel of match-level data of teams that play in the highest German soccer league, the *Bundesliga*. We agree with Kahn (2000) that the sports business is an ideal labor market laboratory. Due to the frequency and regularity of athletic events, large and reliable data sets that contain accurate measures of individual and team performance are readily available. Further, unlike in many other industries, hypotheses may be tested in relatively controlled field environments. Competing teams in any sport tend to have similar organizational structures and pursue similar or identical objectives, and the production process is clearly defined by a detailed catalogue of rules of the game, which are enforced by independent referees (Koning (2003)). We argue that soccer offers an exceptionally suitable platform for investigating the impact of a team's stock of specific knowledge on team performance.

Unlike sports in which team productivity depends on disjunctive tasks (e.g., baseball), the output of a soccer team is clearly driven by the interaction of its members' conjunctive tasks. An offense player will be unlikely to score if his teammates do not support him with strategic passes. Similarly, a defender can hardly avoid conceding a goal if his team's midfielders constantly make misplaced passes (Franck and Nüesch (2010)). Also, the different tactical positions are not as narrowly circumscribed as in, e.g., baseball or American football (Katz (2001)). In soccer, each player acts mostly according to the responsibilities of his tactical position and interacts mainly with players of adjacent tactical

positions. However, depending on the situation, any player can get involved in offense or defense and may interact with any other team member.

The required interaction of specialized but relatively flexible tactical roles, combined with the speed of the game, makes team-specific human capital critical in professional soccer. When there is no time to verbally coordinate individual actions, the players need to have the ability to cooperate almost intuitively if they are to collaborate efficiently. When we think of a player who wants to pass the ball to a teammate the passer has to anticipate where the receiving player is going to run, and equally, the latter has to predict where the passer is going to kick the ball. Simultaneously, both players have to perceive and even anticipate their opponents' actions in order to adapt to them. In a professional soccer match, for a team to be successful a countless number of these types of actions must be conducted very quickly, leaving little time for explicit communication. The high interaction level requires that teammates have shared experience in playing as a team. Although in professional soccer the final team performance occurs in front of thousands of spectators in the venue and is also televised, the implicit character of team-specific human capital still creates causal ambiguity, which means that it is all but impossible for both the team and its rival to determine what exactly generates superior performance (Reed and DeFillippi (1990); Powell, Lovallo, and Caringal (2006)). Furthermore, the pool of potential substitute resources for team-specific human capital is limited because all competing teams use identical technologies, as defined by the precise specification of the production process of a soccer match.

3.1 Sample

Our sample consists of a panel of 1,177 players. We recorded these players in 50,412 player-match-observations from the 2001/02 season to the 2006/07 season of the *Bundesliga*. From the player-match data set, we aggregate the team's average in team-specific human capital and other team composition variables for 3,672 team-match-observations. In each season, which begins in August and runs through May of the following year, each of the league's 18 teams plays each other team in one home and one away match, resulting in 34 matches per team and per season. Due to the relegation of the three lowest-ranked teams and the promotion of the three highest-ranked teams of the second *Bundesliga* at the end of each season, our study sample comprises 25 teams. Most of the data we use in this study are available on the Internet (*www.fussballdaten.de*). We obtained the players' market values from special editions of *Kicker,* the most prominent German soccer magazine.

3.2 Dependent Variable

Team performance. In a soccer match, team performance is always a relative outcome that reflects the playing quality of one team compared to the opposing team. Each team's output is easily measurable, because the team that scores more goals than its opponent wins three points and the losing team gets zero points. If both teams score an equal

number of goals, then the game is counted a draw and both teams get one point. Within a league, teams are ranked according to the sum of their points won. If two or more teams have an equal number of points, then their relative positions are determined by the difference between goals scored and goals received. Hence, each team has an incentive not only to win the match, but also to do so with a goal difference that is as large as possible. Because our data set allows investigation on the team-match level, we consider the goal difference the best way to reflect the presence of a competitive advantage.

Additionally, we run an ordinary least squares (OLS) regression with the number of points as dependent variable. We use OLS models rather than ordered probit and ordered logit models with the final result (win, draw, loss) as the dependent variable because of the incidental parameters problem. Unlike in the linear case, the non-linear ordered probit and logit models do not estimate consistent coefficients in models with fixed effects and limited time periods (Verbeek (2008)).

3.3 Independent Variables

Team-specific human capital. It is difficult to accurately distinguish between specific and general human capital because both are simultaneously developed and both can be expected to influence a team's performance. However, although a player's team-specific human capital is clearly expunged the moment he leaves his team, he does continuously gain experience in the form of general human capital throughout his entire career, regardless of the number of clubs he plays for. Therefore, we consider that the number of previous appearances in league matches played for the current team is a reasonable proxy of a player's team-specific human capital. On the team-match level, we build the average of this measure over all fielded players. The Appendix provides a sample calculation.

We also include the squared value of the variable to allow for the hypothesized concave form of the relation between team-specific human capital and team performance.

Heterogeneity of team-specific human capital. As a proxy variable for a team's heterogeneity in terms of team-specific human capital, we calculate the standard deviation of all fielded players' number of prior appearances for the current team on a team-match level[1]. We use this variable to test hypothesis 3 and to gain further insight into the relation between the heterogeneity of team-specific human capital and team performance.

3.4 Control Variables

Difference in general human capital. We control for a team's stock of general human capital because we question that a newly composed team, one with virtually no specific human capital at all but with a lot of expensive superstars (i.e., a larger stock of general human

1 Our conceptualization is in line with Berman, Down, and Hill (2002), who also used the standard deviation to measure team experience heterogeneity.

capital), is likely to beat a team that has a great deal of experience playing together (i.e., a larger stock of team-specific human capital) but is comprised of unknown average players.

We argue that a player's general human capital can be approximated by our predicted start-of-season market values. In the *Bundesliga,* clubs do not have to publish their players' market values. However, *Kicker* began to publish respective proxies in the mid-1990s. These proxy measures are likely to be consistent because the market values have been estimated in a systematic manner for several years by largely unchanged editorial staff. They have already been used in several empirical studies on the German soccer league (see Lehmann and Weigand (1999); Swieter (2000); Forrest and Simmons (2002); Hübl and Swieter (2000); Littkemann and Kleist (2002); Haas, Kocher, and Sutter (2004); Franck and Nüesch (2011a); Franck and Nüesch (2011b)).

A player's performance is not only observable and transparent during the match, but also, the training sessions are usually open to the public (Franck (1995)). With minimal information asymmetries on a player's capabilities, we expect the predicted market values to adequately encompass all general human capital components. Since market values represent the price that another team is willing to pay for the services of a certain player, market values should accurately reflect that player's transferable general human capital. Market values do not incorporate team-specific human capital because team-specific human capital is by definition immobile. Forrest and Simmons (2002) show that in European soccer, high market values clearly increase field success.

Following Depken (1999), we use the logarithm of estimated market values as a control variable for the team's stock of general human capital. Market values are expressed in 2003 Euros and are adjusted for inflation. Because the match is our unit of observation, we can take the opposing team's stock of general human capital into account to calculate the teams' relative advantage. We then take the logarithm of each team's sum of its fielded players' estimated market values and then calculate the difference between the two opposing teams.

Home advantage. To control for potential home field advantage, we include a dummy variable that takes the value of one for a home match and zero for an away match. Carmichael and Thomas (2005) show that home field factors, e.g., a dominant fan base in the home stadium and familiarity effects, positively influence the effectiveness of the home team.

We also control for unobserved time-constant heterogeneity by including both home and away team fixed effects, and we use seasonal team fixed effects to account for potential time effects. Standard errors are White robust and clustered at the match-level to account for potential error correlation between the two team observations of the same match.

3.5 Analysis And Results

Table 1 presents descriptive statistics and correlations. The correlation matrix indicates that there is a correlation above 0.9 among the independent variables only for our team-specific human capital measure and its square with respective variance inflation factors (VIFs) of above ten[2]. Despite the multicollinearity, we do not drop the squared terms from our model, since the requirement of unbiased estimates is not necessarily violated. High degrees of correlation between the independent variables are really no different from using a small sample size; the variance of the coefficient estimates increases in both cases, which may lead to statistical insignificance (Wooldridge (2003)). Further, we argue that the squared term should not be omitted, because theoretical arguments and empirical evidence support our predictions that the relation is concave in shape. Ignoring these nonlinearities would lead to biased estimates.

Table 1: Variables, descriptive statistics, and pearson correlation coefficients

Variable	Mean	SD	Min	Max	1	2	3	4	5	6	7
1 Goal difference	0.00	1.83	–6	6	1.00						
3 Points	1.38	1.32	0	3	0.87	1.00					
4 Team-specific HC	61.28	19.15	15.29	140.29	0.13	0.13	1.00				
5 Team-specific HC squared	4.12	2.64	0.23	19.68	0.13	0.13	0.98	1.00			
6 Heterogeneity of team-specific HC (10^{-2})	0.55	0.19	0.15	1.33	0.11	0.10	0.79	0.77	1.00		
7 Difference in general HC	0.00	0.67	–1.91	1.91	0.33	0.30	0.45	0.45	0.34	1.00	
8 Home advantage	0.50	0.50	0	1	0.25	0.23	0.02	0.01	0.00	0.02	1.00

Notes: 3,672 observations (all matches played in the first German soccer league during six seasons, 2001/02 until 2006/07). The model also includes fixed effects for the home team, the away team and the season.

Table 2 shows the estimation results from the regression analyses. Based on the tenets of the resource-based view of the firm, in *hypothesis 1* we predict that team performance is positively affected by the accumulation of team-specific human capital. Our data supports this relation. The team average of prior appearances for the current team, which we use as our proxy variable for a team's stock of team-specific human capital, significantly increases team performance in both specifications. Furthermore, in *hypothesis 2* we hypothesize that the performance increments are subject to diminishing returns due to typical learning processes. Because the squared term of our team-specific human capital measure is significantly negative, our results suggest that there is such a concave relation between a team's

2 A common rule of thumb says that only VIFs above a value of ten may be a reason of concern (see Neter, Wassermann, and Kutner (1989)).

stock of team-specific human capital and team performance. Here again, the respective coefficients are not subject to a particular specification. Shared experience in working as a team seems to matter even beyond the positive impacts of general human capital.

Table 2: The influence of team-specific human capital on team performance

	Goal Difference	Points
Explanatory variables	**(1)**	**(2)**
Team-specific HC	0.015*	0.013**
	(0.008)	(0.006)
Team-specific HC squared	–0.112*	–0.081*
	(0.064)	(0.047)
Heterogeneity of team-specific HC (10^{-2})	–0.286	–0.197
	(0.255)	(0.190)
Difference in general HC	0.400***	0.196**
	(0.143)	(0.100)
Home advantage	0.888***	0.612***
	(0.077)	(0.056)
Home team fixed effects	yes	yes
Opposition team fixed effect	yes	yes
Seasonal fixed efffects	yes	yes
R^2	0.20	0.17
Observations	3,672	3,672

Notes: Displayed are empirical results from an ordinary least squares (OLS) regression. Standard errors in parentheses are heteroskedasticity robust and clustered at the matchlevel. Significance levels (two-tailed): * 10%, ** 5%; *** 1%.

Concerning the specification of the team-specific human capital variable, we could argue that team-specific human capital is developed not only at the competition stage, but also at the preparatory stage, which is seemingly not accounted for in the specification of the team-specific human capital variable. At the preparatory stage, a continuous process of exercising and training takes place in which all players on the roster are involved. However, at the competition stage, only a limited number of players, usually those who are currently considered to be most valuable to the team, are selected by their coach to perform for their team. To check the robustness of our results, we calculate a model based on the players' number of seasons with the current team, which also takes potential learning processes at the preparatory stage into account. Nevertheless, the results are consistent with the findings presented in *Table 2*.

Hypothesis 3 suggests that the heterogeneity of team-specific human capital might negatively affect team performance. Although the coefficients are negative, they provide very little

support for our prediction because they are consistently insignificant. The interpretation of the insignificant effect is ambiguous, since there may either be no effect at all or both positive and negative effects of heterogeneity in terms of team-specific human capital tend to cancel each other out.

Looking at the control variables, we find that the difference between the opposing teams' logarithmic sum of estimated player market values influences team performance in a positive and statistically significant way. This result confirms our expectation that a team's performance in soccer also depends on a team's relative advantage in its stock of general human capital.

Moreover, we find evidence of a substantial home field advantage. All else equal, a team scores approximately 0.9 goals more in a home match than in an away match.

4 Discussion And Conclusion

In this paper, we empirically investigate if a team's shared experience, i.e., its stock of team-specific human capital, as an intangible and unobservable resource, affects team output. In contrast to prior studies, we are able to measurably distinguish between the performance effects of general and specific human capital components. We use a large panel data set of professional soccer teams from the German *Bundesliga* as an example of highly interactive teams. This sample makes it possible for us to examine how team-specific human capital qualifies as a critical resource for achieving a competitive advantage. According to the resource-based view, such a critical resource must add value to the firm, it must be rare, it must be inimitable, and it must not be substitutable by an alternative resource (Barney (1991)). Based on these tenets, we hypothesize a positive relation between a team's stock of team-specific human capital and team performance. Our empirical investigation provides support for this prediction, indicating that team members should generally be retained in the team. Furthermore, we show that the relation between team-specific human capital and team performance is not linear in shape, but instead is concave. This finding can be convincingly explained by learning effects. These findings support the notion of team-specific human capital as constituting a critical resource according to the resource-based view of the firm. As an intangible resource, team-specific human capital is able to induce and, at least temporarily, sustain a competitive advantage, because it is relatively safe from being imitated by competitors or substituted by another resource.

We also find that team performance in soccer depends on the relative advantage in a team's stock of general human capital. This result is hardly surprising. However, in contrast to team-specific human capital, it shows that general human capital is freely transferable because it is valuable to all teams (see Williamson (1984)). According to the resource-based view, this mobility makes general human capital unlikely to result in a sustained competitive advantage.

More interestingly, we find a negative, but statistically insignificant, impact of the heterogeneity in terms of team's team-specific human capital on team performance. Thus, given

the highly interactive production process of a soccer match, our prediction that a high degree of homogeneity is beneficial cannot be confirmed. This result does not imply that a similar experience level among team members in playing for the current team is completely irrelevant. It is possible that in our case the positive and negative effects neutralize each other, leading to a zero net effect.

Our finding that a player's specific relationships with teammates matter implies that the loss of team-specific human capital in the case of a transfer should be accounted for in any club's investment decision regarding the engagement of new players (Clarke and Madden (1988); Rosen and Sanderson (2001)). Failing to consider this aspect may explain the occasional observation that a soccer player turns out to be a flop after a transfer to a new team because he does not live up to expectations. Moreover, the specificity of certain employment relationships and their interdependence give rise to difficulties in evaluating investment decisions (Vrooman (1996)).

Jovanovic's (1979) matching theory may provide an alternative explanation for our results. If we assume that in general, unproductive employees will be terminated and productive employees will be prolonged, then we must conclude that tenure should be a good indicator of productivity. Or, as Flinn (1986) put it: "The longer an employment spell continues, the more precise is the estimate of the match." We are unable to distinguish between the impact of the specificity of the relationships and the impact of the precision of the match estimate because both increase with tenure and both have a positive effect on team performance. However, the observation that team-specific human capital is positively correlated with team performance in a highly transparent production process with minimal information asymmetries concerning the players' performances and capabilities suggests that performance increments are more likely due to team-specific human capital. We argue that in soccer, precise ex ante information with which to estimate a match is publicly available. In non-sports industries, external employers have only limited access to ex ante information and must therefore deduce less precise estimates of the real productivities (Barron and Loewenstein (1985); Greenwald (1986)). An employer continuously gains information on an employee's initially unknown performance-relevant characteristics. However, it is unrealistic to assume that this information will be transferred to a new employer if it can be kept private (Wilde (1977); Johnson (1978)). Thus, information asymmetries between the current employer and potential future employers may explain the tendency to prolong existing employees, but this argument is hardly applicable to soccer teams.

Another peculiarity of soccer that may limit the transferability of our results to other industries concerns the issue of moral hazard in teams (see, e.g., Holmström (1982)). Almost perfect monitoring in the stadium and on TV compels players to strive for excellence and impedes collusion between some of the team's players. However, in most other professional contexts, moral hazard problems are more likely to emerge because the employees' actions are less observable.

To explore the transferability of our results, we advocate further investigation of the relation between the composition of team-specific human capital and team performance in other contexts involving teamwork.

Appendix

Sample calculation of our proxy variable for a team's stock of team-specific human capital

$$\textit{Mean of all fielded team members' team – specific human capital on a team-match level} = \frac{\sum_{\textit{All fielded players}} \textit{player i 's number of prior appearance for team}}{\textit{Number of fielded players}}$$

For illustration purposes, consider the following (real) example of Borussia Dortmund on the first match day of the 2001/02 season. The fielded players (starting lineup as well as the substitute players) have the following histories with Borussia Dortmund.

	Player	Prior appearances for Borussia Dortmund
1.	Jens Lehmann	76
2.	Christian Wörns	50
3.	Jan Derek Sörensen	10
4.	Dede	85
5.	Tomas Rosicky	16
6.	Giuseppe Reina	58
7.	Miroslav Stevic	68
8.	Jörg Heinrich	31
9.	Jan Koller	1
10.	Lars Ricken	187
11.	Marcio Amoroso	1
12.	Jürgen Kohler	170
13.	Stefan Reuter	218
14.	Evanilson	54

We note that "Prior appearances for Borussia Dortmund" take into account only the period during which the player has continuously stayed with his current team. If a player has already played for the current team in the past, then changed to another team before

returning to his current time, we factor in only the period following his most recent transfer. In our example, Jörg Heinrich played for Borussia Dortmund from the 1995/96 through the 1997/98 season. In the following two season, he played in Italy for AC Florence and then returned to Dortmund for the 2000/01 season. According to our conceptualization, we only consider his experience with Borussia Dortmund after his transfer from Florence. Thus, on the first match day of the 2001/02 season, it is his 31st appearance in a league match with Borussia Dortmund.

These data yield the following calculations of Borussia Dortmund's mean of team-specific human capital:

$$\frac{76 + 50 + 10 + 85 + 16 + 58 + 68 + 31 + 1 + 187 + 1 + 170 + 218 + 54}{14} = 73.21$$

We do not weight the player-team specific human capital with the playing time on the pitch for two reasons: first, the playing times are similar as the number of possible substitutions is restricted to three. Second, and even more important, the team's stock of team-specific human capital would be affected by red cards, which would reduce the team's sum of playing time and would therefore distort the effect of team-specific human capital.

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