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WORKING PAPER

The effectiveness of coach turnover and the effect on home team advantage, team quality and team ranking.

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Abstract

The effectiveness of coach turnover on team performance is widely discussed in the literature due to the indirect impact of a team's performance on a club's revenues. This study examines the effect of coach turnover within a competition season by focusing on the change in team quality and the change in home team advantage under the new coach. The change in team quality or home team advantage can vary according to the team (team specific) or might be an independent quantity (non-team specific). We estimated nine possible regression models, given no change, team specific change and non-team specific change in quality or home team advantage. The data are match results of Belgian male soccer teams playing in the highest national division during seven seasons. Results point to a team specific effect of a new coach on a team's quality. This paper further contributes by evaluating the new coach's success with regard to whether his ability to improve team quality also results in a better position of the team in the final ranking. A new coach will be able to improve the ranking of the team if the improved team quality under the new coach renders a positive team quality.

Keywords

Managerial change; home team advantage; team performance; team quality; regression model, individual match data, team ranking

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Introduction

Although performances on the field are the prime interest of sport teams, professional sports is big business and sport performances will have, directly or indirectly, an impact on the financial revenues of soccer clubs. Obtaining lucrative sponsorship contracts, the amount of revenues from broadcasting rights and proceeds from merchandising are mainly dependent on how well teams are performing. Strong teams will probably have more revenues than weaker teams. Moreover, based on their performances in national leagues and cup competitions, clubs qualify for the lucrative Champions League (a highly valued European competition with only a selected number of European teams) or the UEFA-Cup (the second most important international competition for European soccer clubs). The quality of the team indirectly affects the amount of revenues that allow clubs to acquire highly talented players and thus, to improve performances [12]. The economics of professional team sports has received a lot of attention in literature [7, 9, 18].

Coaches are held responsible for the performances of their team. The task of the coach is to train the players in order to win games and to end as highly as possible into the final league ranking [13]. Disappointing performances not only will result in a lower final ranking than previously expected, but they indirectly affect the amount of revenues of the club. If the coach is not able to fulfill the performance expectations, clubs might consider to fire the coach. Coach turnovers are a frequently occurring phenomenon in professional sports. Most researchers agree that bad results are the major determinant of a turnover [1, 17]. By changing coach, clubs hope to bring about improvement in performance [1, 17] and to increase the position of the team in the league ranking.

Amongst team sports, the effect of coach turnover on team performance has been widely studied. Most studies examined the effectiveness of dismissing the coach by focusing on outcome of games or on winning percentages [1, 3, 5] . More recent approaches are based on econometric modeling of individual match results [2, 10, 11, 13]. These approaches take into account the quality of the opposing team and avoid problems of how to construct a control group.

This study adopts the econometric approach modeling of individual match results. We studied the effect of coach turnover within a season on team quality and home team advantage. First, we expected a relationship between team quality and team performance. The higher the quality of the team, the better the performances. It is reasonable to assume that the composition of a team remains more or less constant within a season. Therefore, we assume that any quality changes after a coach turnover might be attributed to the effect of hiring a new coach. Second, many studies have proven the existence of home team advantage [15, 16]. Crowd support is an important determinant in the home advantage literature [6]. De Dios Tena and Forrest [10] suggested that crowd support is also relevant in the process of managerial dismissal. We assume that any home team advantage changes after a coach turnover might be attributed to the effect of home crowd. In that case, the home crowd may become an important stakeholder to deal with.

Literature on the effect of coach turnover on team quality and home team advantage is scarce. Some studies focused on the relationship between team quality and home team advantage without considering the effect of coach turnover [4, 14]. Only two papers addressed the effect of coach turnover within the season on team quality and/or home team advantage [10, 13]. Koning [13] estimated a regression model using goal differences to examine if there was a significant turnover effect on the change in team quality and home team advantage. The model corrected for any bias due to the non-random schedule of play by incorporating the quality of the opponent team. Koning [13] defined a coach turnover as successful if both the change in team quality and the change in home team advantage were positive. Except for one season of five, there was no significant positive coach effect. De Dios Tena and Forrest [10] contributed to the debate of managerial change in soccer by raising the hypothesis that crowd support is important in the determination of match outcomes when a coach turnover occurs. Their probit model splits up the impact of a coach turnover into an effect on home performances and into an effect on away performances. The results suggested that new coaches have a modest positive impact on the match results played at the home stadium.

Similar to Koning [13], our study examines the effect of coach turnover by focusing on the change in team quality and the change in home team advantage under the old and new coach. The change in team quality can vary according to the team (team specific) or might be an independent quantity (non-team specific). Likewise, the improvement in home team advantage might vary with the team (team specific) or might be independent (non-team specific). Given no change, team specific change and non-team specific change for both team quality and home team advantage, there are nine possible regression models that can be estimated (see Table 1). Koning [13] estimated only seven of these nine possible regression models, omitting models with team specific change on one dimension and non-team specific change on the other dimension. This paper rectifies this omission by also estimating models allowing for a) team specific change in team quality and non-team specific change in home team advantage and b) non-team specific change in team quality and team specific change in home team advantage.

Apart from extending Koning's work [13] by estimating two additional models, this paper contributes to Koning's paper [13] in another way. Koning [13] defines the success of a new coach in terms of a simultaneous improvement in home team advantage and team quality, as inferred from the goal difference regression model. Given the financial relevance of the team's final ranking, we argue that a new coach's success should be discussed with regard to his ability to improve the team's position in the final ranking. Therefore, we study whether a change in team quality and/or home team advantage as estimated by the goal difference model coincide with an important objective of coach replacement, i.e. to achieve a better position in the final ranking. It is important to notice that an improvement in team quality and/or improvement in home team advantage resulting in a higher expected goal difference might not result in an improvement in ranking. In short, the (change in) team quality and (change in) home team advantage are expressed in function of expected goal difference. In contrast, the ranking is based on whether a team wins a game (3 points), draws (1 point) or looses (0 points). Hence, for the ranking, only the *sign* of the goal difference matters, not its size. For example, imagine that a team's quality under the new coach improves from 1 to 2, meaning that the team under the new coach is expected to win from an average team on neutral ground with two goals difference. Winning with a larger goal difference from an average team does not necessarily imply that the team wins more games and hence increases in ranking. Therefore, unlike Koning [13], this paper aims to gap the bridge between the new coach's ability to change a team's quality and/or its home team advantage and his ability to improve the team's ranking.

Data

Our data consist of the match results of Belgian male soccer teams playing in the highest national division during seasons 1998–1999 to 2004–2005. Data were obtained using secondary sources such as soccer journals, newspapers and internet soccer websites. We identified 45 within-season coach turnovers upon the seven seasons.

Before presenting the models estimated on the data, we briefly describe the characteristics of European soccer which matter when modeling goal differences per match as a way to assess the effect of coach turnover. In European soccer, the competition schedule is fixed and known at the start of the competition season. The competition is balanced so that every team competes against each other team twice: once at home and once away. A win is rewarded with three points and a draw with one point. No points are awarded when the team loses the game. A model estimating the coach effect should correct for any bias caused by the non-random order of play and quality differences of opponents faced under the old and new coach [13]. Therefore, the model should include an explanatory variable that corrects for the quality of the opposing team. Models that are based on individual match-level data allow this.

Results

Model selection

The focus of this paper is the change of two parameters after coach turnover: team quality and home team advantage. The model that we used is an extension of the model of Clarke and Norman [8] and Koning [13].

Analogous to Koning [13], we restricted our attention to within-season coach turnovers. Given that the composition of a team stays more or less constant during a season, any changes in performances can be attributed to the change of coach. Hence, all regression models are estimated for each season separately as it is unreasonable to assume that the composition of a team remains constant between seasons. The first regression estimates Clarke and Norman's model [8] to predict the goal difference for each single game within a season. The goal difference D_{ij} is the number of goals scored by the home team i minus the number of goals scored by the away team j. This goal difference D_{ij} is explained by the home team advantage of team i playing home, the difference in quality between the home team i and the away team j (θ_i - θ_j) and a mean zero error term with constant variance ε_{ij}:

$$D_{ij} = h_i + \theta_i - \theta_j + \varepsilon_{ij} \qquad (1)$$

h_i can be interpreted as the expected win margin if team i would play at home against a team of equal quality, $\theta_i - \theta_j = 0$. To identify all parameters in Equation 1, a restriction is imposed on the quality parameters, $\Sigma_i \ \theta_i = 0$. As such, the quality parameters indicate deviations from a hypothetical average team with quality 0. θ_i is the expected goal difference if team i would play against the average team on neutral ground. If D_{ij} is positive, home team i is expected to win. However, if D_{ij} is negative, the opponent team j is expected to win the game.

Similar to Koning [13], Clarke and Norman's model [8] is extended to allow measuring the effect of coach turnover on team performance. More specifically, the effect of coach turnover on the quality of the team and its home team advantage are investigated. After all, similar to Koning [13], the team quality and home team advantage are assumed to be dynamic during the season and potentially affected by a coach turnover. The change in quality of a team might vary according to the team (team specific) or might be an independent quantity (non-team specific). Likewise, the change in home team advantage might vary with the team (team specific) or might be an independent quantity (non-team specific). Non-team specific change in home team advantage and non-team specific change in team quality imply that the amount of change for all teams in a season is assumed to be equal.

For teams that changed a coach, we included a team specific/non-team specific change in home team advantage (k_i or k) and/or a team specific/non-team specific change in team quality after coach turnover (ψ_i or ψ). For example, Equation 2 expresses the home team advantage for team i under the new coach (superscript n) as the sum of the home team advantage of team i under the old coach (superscript o) and a non-team specific change in home team advantage due to coach turnover.

$$h_i^n = h_i^0 + k \qquad (2)$$

$$h_i^n = h_i^o + k_i \qquad (3)$$

$$\theta_i^n = \theta_i^o + \psi \qquad (4)$$

$$\theta_i^n = \theta_i^o + \psi_i \qquad (5)$$

Table 1 lists the basic Clarke and Norman model (no change in home team advantage and no change in team quality; lower right corner), the six models estimated by Koning [13] and two new models (models in *italics*). Contrary to Koning [13], we also tested the non-team specific change in home team advantage versus team specific change in team quality and vice versa.

Insert Table 1 about here

Table 2 presents a summary of the nine different regression models estimated for each of the seven seasons. The last two columns present the results for the two new models. Column k_i, ψ reports a regression model fixing the change in team quality to be equal across all teams with coach turnover but allows for team specific change in home team advantage. Column k, ψ_i imposes the constraint that the change in home team advantage is equal for all teams that changed a coach but allows for team specific change in team quality.

Insert Table 2 about here

For the Clarke and Norman model (h, θ), we tested for normality, multicollinearity, heteroscedasticity and autocorrelation. For all seasons, the Q-Q plot of the residuals indicated that the residuals are normally distributed. No multicollinearity problem was observed as the condition index for each season is well below 20, i.e., taking values from the interval [2.51, 2.66]. For all seasons, a heteroscedasticity test rejected the hypothesis of errors that are dependent of the regressors with probability in range [0.55, 0.82]. Finally, the errors were not autocorrelated. The hypothesis was tested that the error term v_t is generated by a first-order autoregressive process $v_t = -\gamma_1 v_{t-1} + \varepsilon_{ij\_t}$ where $|\gamma_1| < 1$ and ε_{ij_t} is a sequence of independent normal error terms with mean 0 and variance σ^2; $\varepsilon_{ij\_t} \sim$ i.i.d. $N(0, \sigma^2)$. The Durbin-Watson d statistic is used to test the null hypothesis H_0: $\gamma_1=0$. Each error was uncorrelated with the error immediately before it, as reflected by all Durbin-Watson D statistics being close to two, [1.75, 2.08].

To test which of the models significantly outperform another model, general F-testing was applied to the regression results per season. Table 3 provides the number of seasons for which the model in the row and the model in the column significantly differ at $\alpha = 0.05$. First, for all seasons we tested whether any of the extensions significantly outperform the basic Clarke and Norman model (h, θ); see column 1 in Table 3. Additional F-tests (Table 4) were performed to select the best model among the models significantly differing from the Clarke and Norman model (h, θ).

Insert Table 3 about here

Insert Table 4 about here

First, for four out of seven seasons, both the model with team specific change in team quality (ψ_i) and the model with same change in home team advantage and team specific change in team quality (k, ψ_i) significantly outperform the basic model of Clarke and Norman (h, θ). Second, additional F-tests allow to select from the two remaining models: (ψ_i) and (k, ψ_i). From Table 4 we learn that the model with same change in home team advantage and team specific change in team quality (k, ψ_i) never significantly outperforms a model including only team specific change in team quality (ψ_i). This finding is in favour of the (ψ_i) model rather than the (k, ψ_i) model. Moreover, for three out of seven seasons, the model allowing for team specific change in team quality (ψ_i) significantly outperforms the model with non-team specific change in team quality (ψ). The best model in this study to predict the expected goal difference is Clarke and Norman's model extended with team specific change in team quality (ψ_i):

$$D_{ij} = h_i + \theta_i + \psi_i - \theta_j + \varepsilon_{ij} \qquad (6)$$

Assessing coach turnover success

Starting from his best model (k, ψ), Koning [13] defined a coach turnover as successful if both the change in non-team specific home team advantage and the change in non-team specific quality are positive: ($k > 0$) and ($\psi > 0$). Our best model (ψ_i) does not include change in home team advantage but includes a team specific change in quality (see Equation 6). As such, our measure of coach turnover success is team specific and it is only defined by a positive team specific change in team quality: $\psi_i > 0$. Over the seven seasons, for 36 of the 45 teams the team quality improved after coach turnover. For 8 of these 36 teams the team quality improvement was significant at $\alpha=0.05$ (and additional 5 teams at $\alpha=0.10$) as reflected by the significance of the ψ_i parameter in the regression models. However, 24 of the 36 teams that improved team quality succeeded in achieving a better final ranking, irrespective of whether the change in team quality was significant. Reflecting on the practical relevance of the goal-difference model, a coach turnover might be regarded as successful if the team's position in the final ranking improves. After all, the profits of the club are influenced by the team's position in the final ranking. Therefore, a coach turnover might be successful if the increase in team quality, irrespective of the significance of the change team quality, also results in an increase in the final ranking. The association between the change in team quality and change in ranking was tested by assessing the significance of the asymmetric Somer's d_{yx} association statistic. The change in team quality ψ_i (Equation 6) was recoded as a dummy *inc_qua* taking value '1' if the team quality improved and value '0' if the team quality under the new coach stayed equal or had decreased. Likewise, the change in ranking was also coded as a dummy *inc_rank* taking value '1' if the team's final ranking improved under the new coach and taking value '0' if the team's final ranking decreased or stayed equal. The Somer's d_{yx} statistic indicates a significant positive relationship between change in team quality and change in ranking (Somer's d_{yx} = 0.5556, p=0.0010, N=45).

Next, we test for a moderation effect of the team quality under the new coach θ_i^n upon the association between change in team quality ψ_i and change in ranking under the new coach (Table 5 and Table 6). From Equation 4 and Equation 6, it seems important that the change in team quality results in a *positive* team quality under the new coach ($\theta^n_i>0$). After all, only when team quality is positive, the team is expected to score more than the average team on neutral ground (cf. interpretation of θ_i). The association between change in team quality and change in ranking turned out to be weaker and no longer significant when controlled for a negative team quality under the new coach, i.e. d_qua_n=0 (Somer's d_{yx}= 0.2571, p=0.0856, N=22). When the new coach is able to improve the team quality but the new team quality remains negative, the team is still expected to score less than an average team on neutral ground. In such a situation, the probability to improve the team's ranking is small. In contrast, the association between change in team quality and change in ranking given a positive team quality under the new coach (i.e. d_qua_n=1) is still significant and even more pronounced than without correcting for the moderation effect (Somer's d_{yx} = 0.8571, p=0.0528, N=23 versus Somer's d_{yx}=0.5556 unconditional). To conclude, whether the new coach will be able to improve the ranking of the team depends on whether the improved team quality renders a *positive* team quality.

Insert Table 5 about here

Insert Table 6 about here

Discussion

Model selection: discussion

Koning's model [13] included non-team specific change in home team advantage and non-team specific change in team quality. Our best model (see Equation 6) does not indicate that a change in a team's home advantage under the new coach substantially contributes to predict match goal differences. The absence of *team specific* change in home team advantage might be explained by Clarke and Norman's [8] finding that home team advantage only has a borderline significant *team* effect. The absence of a *non-team specific* change in home advantage can also be explained by Clarke and Norman [8]. As (the change in) quality affects a team's performance every match, and (the change in) home team advantage only for half the matches, the importance of (the change in) home team advantage for predicting goal differences will always be inferior to the predictive importance of (the change in) quality. Irrespective of the number of times that a team's home team advantage effect is accounted for, the magnitude of the home team advantage has been shown to be about three times as small as the effect of team quality [8]. Finally, recall that the general F-testing retained the (γ_i) and the (k, γ_i) models as models outperforming the original Clarke and Norman model [8]. The (γ_i) model was preferred to the (k, γ_i) model because there was no significant difference between both models as proved by the F-test. All in all, there might be a small effect of the new coach on a team's home team advantage, but the latter has only limited value in predicting goal differences and as a result a team's performance or ranking.

Apart from this econometric explanation for the absence of home team advantage change, it's our belief that the change in home team advantage resulting from a change in coach could only be a second-order effect. Such a second-order effect could perhaps result from a new coach bringing bigger attendances through improved team quality and thus more crowd support.[1]

Assessing coach turnover success: discussion

Our results seem to indicate that there is a stronger coach effect than reported by Koning [13]. Koning [13] discovered that, except for one season (1993-1994), coach turnovers had no positive effect as the new coaches were unable to improve both team quality and home team advantage. According to our results, 24 teams out of 45 experienced a positive coach turnover effect as reflected by a simultaneous quality improvement and increase in ranking. Notwithstanding our evidence of a substantial coach effect, a straight comparison of our results to those of Koning [13] is unfair. Restricting the coach effect to be team independent, Koning [13] rephrases the research question 'Is there a significant coach effect for team *i* that changed coach?' to 'Is there a significant coach effect for *all* teams that changed coach?' It's clear that the odds of finding significant coach effects under our research question (first question) are much higher than under Koning's research question (last question).

Conclusion

This study investigated the effect of coach turnover within a competition on the change in home team advantage and the change in team quality under the new coach using regression models that predict goal differences. Koning [13] estimated only seven of nine

[1] We would like to thank one of the anonymous reviewers for mentioning this potential second-order effect.

possible regression models. This paper also estimated the two omitted models allowing for non-team specific change in home team advantage versus team specific change in team quality and vice versa. The results point to a team specific effect of a new coach on a team's quality. Conversely, Koning's model [13] included non-team specific change in home team advantage and non-team specific change in quality. Given that we reach a different best model, further research is warranted to detect the best regression model predicting goal differences irrespective of the data characteristics.

Similar to Koning [13], the goal-differences regression model is employed to assess the success of the new trainer. For *some* teams there is a significant coach effect as reflected by a positive team specific change in team quality under the new coach. For other teams there was no significant coach effect. Conversely, Koning [13] only finds a coach turnover effect for one season for *all* teams as reflected by both a positive non-team specific change in quality and a positive non-team specific change in home team advantage.

This paper further contributes to Koning's paper [13] by evaluating the new coach's success with regard to whether his ability to improve team quality also results in a better position of the team in the final ranking. A new coach will be able to improve the ranking of the team if the improved team quality under the new coach renders a *positive* team quality. The association between the quality parameters of the regression model (ψ_i, θ_i^n) and the change in ranking under the new coach demonstrates the practical value of the goal difference model to evaluate the effectiveness of coach turnovers.

The current paper raises several interesting questions for further research. First, rather than measuring the association between the regression parameters (ψ_i, θ_i^n) of the goal difference model, future research could use the regression parameters ($\psi_{i,}$ θ_i^n) to predict a team's absolute change in ranking (continuous outcome) or a team's ability to improve in ranking or not (binary outcome). By estimating the goal difference model on all games under the old coach and some but not all (e.g. four) games under the new coach for team *i*, an initial estimate of ($\psi_{i,}$ θ_i^n) is obtained which in turn can be used to predict the expected change in ranking for team *i*. This way, a club could measure the new coach's success shortly after coach turnover, allowing to detect the need to fire the new coach if the expected change in ranking would turn out to be negative or insufficient. Second, further research could assess the effectiveness of a coach turnover in terms of final ranking by simulating the probability distribution of the final ranking if there would have been no coach turnover. The final ranking can be presented as a percentile of that probability distribution[2]. Third, our results have shown that coach turnover is successful if the new coach is able to increase the team quality and if the new team quality is positive. Future research should address under what conditions (team characteristics, coach characteristics, …) the new coach is able to do so.

[2] We would like to thank one of the anonymous reviewers for mentioning this future research avenue.

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Table 1. Different regression models estimated per season. Equations are given for a home team *i* that changed coach and plays against opponent *j* who did not change coach.

Change in home team advantage	Change in team quality		
	Team specific	Non-team specific	No change
Team specific	$D_{ij}= h_i^0+k_i+\theta_i^0+\psi_i-\theta_j+\varepsilon_{ij}$; (k_i, ψ_i)	$D_{ij}= h_i^0+k_i+\theta_i^0+\psi-\theta_j+\varepsilon_{ij}$; (k_i, ψ)	$D_{ij}= h_i^0+k_i+\theta_i-\theta_j+\varepsilon_{ij}$; (k_i)
Non-team specific	$D_{ij}= h_i^0+k+\theta_i^0+\psi_i-\theta_j+\varepsilon_{ij}$; $(k ;\psi_i)$	$D_{ij}= h_i^0+k+\theta_i^0+\psi-\theta_j+\varepsilon_{ij}$; (k, ψ)	$D_{ij}= h_i^0+k+\theta_i-\theta_j+\varepsilon_{ij}$; (k)
No change	$D_{ij}= h_i^0+\theta_i^0+\psi_i-\theta_j+\varepsilon_{ij}$; (ψ_i)	$D_{ij}= h_i^0+\theta_i^0+\psi-\theta_j+\varepsilon_{ij}$; (ψ)	$D_{ij}= h_i+\theta_i-\theta_j+\varepsilon_{ij}$; (h, θ)

Table 2. Summary of regression models for seven soccer seasons.

	h, θ	k_i	ψ_i	k_i, ψ_i	k	ψ	k, ψ	k_i, ψ	k, ψ_i
1998/1999									
R^2	0.2787	0.2888	0.3111*	0.3241	0.2814	0.2854	0.2854	0.2941	0.3114*
Adj.R^2	0.1855	0.1818	0.2075	0.2075	0.1856	0.1901	0.1871	0.1849	0.2049
k					0.4837		-0.0546		-0.2122
ψ						0.5955	0.6240	0.7262	
1999/2000									
R^2	0.3420	0.3738	0.3881*	0.3944	0.3471	0.3534*	0.3535	0.3781	0.3883*
Adj.R^2	0.2570	0.2714	0.2881	0.2733	0.2600	0.2672	0.2646	0.2736	0.2855
k					0.5683		0.0957		0.1136
ψ						0.7030*	0.6569	0.5392	
2000/2001									
R^2	0.3939	0.4439*	0.4529*	0.4744*	0.3992	0.4142*	0.4144*	0.4566*	0.4530*
Adj.R^2	0.3157	0.3505	0.3611	0.3642	0.3191	0.3361	0.3338	0.3629	0.3587
k					0.4957		-0.1096		
ψ						0.8103*	0.8638*	0.7980*	
2001/2002									
R^2	0.3860	0.4082	0.4285*	0.4353*	0.3956*	0.4050*	0.4052*	0.4174*	0.4290*
Adj.R^2	0.3067	0.3166	0.3401	0.3328	0.3151	0.3257	0.3233	0.3247	0.3381
k					0.7719*		0.1102		0.2184
ψ						0.8320*	0.7767*	0.7637*	
2002/2003									
R^2	0.3812	0.3865	0.3917	0.3954	0.3812	0.3841	0.3856	0.3906	0.3934
Adj.R^2	0.2975	0.2929	0.2989	0.2942	0.2928	0.2962	0.2949	0.2946	0.2979
k					0.1073		-0.6451		-0.7128
ψ						0.5314	0.8669	0.8397	
2003/2004									
R^2	0.3533	0.3798	0.3696	0.3935	0.3628*	0.3585	0.3629	0.3799	0.3740
Adj.R^2	0.2698	0.2811	0.2694	0.2778	0.2778	0.2730	0.2753	0.2785	0.2716
k					0.7347*		0.6578		0.6610
ψ						0.4344	0.0938	0.0739	
2004/2005									
R^2	0.4087	0.4151	0.4157	0.4237	0.4087	0.4143	0.4166	0.4225	0.4178
Adj.R^2	0.3323	0.3221	0.3227	0.3138	0.3299	0.3362	0.3364	0.3281	0.3226
k					0.0507		-0.4177		-0.4024
ψ						0.4305	0.6404	0.6191	

* indicates that model is significantly different from the Clarke and Norman (h, θ) model at $\alpha = 0.05$.

Table 3. Number of seasons out of seven for which models significantly differ at α = 0.05 using *F*-tests.

	h, θ	k_i	ψ_i	k_i, ψ_i
k_i	1			
ψ_i	4			
k_i, ψ_i	2			
k	2	1		
ψ	3		3	
k, ψ	2			1
k_i, ψ	2			1
k, ψ_i	4		0	0

Table 4: Results of *F*-tests for the models in column per season.

	ψ_i versus h, θ	k, ψ_i versus h, θ	ψ_i versus ψ	k, ψ_i versus ψ_i
1998/1999	F(2.5, 5, 266) = 0.04*	F(2.10, 6, 265) = 0.05*	F(2.48, 4, 266) = 0.04*	F(0.12, 1, 265) = 0.73
1999/2000	F(2.48, 8, 263) =0.01*	F(2.20, 9, 262) = 0.02*	F(2.13, 7, 263) = 0.04*	F(0.09, 1, 262) = 0.77
2000/2001	F(3.14, 9, 262) <= 0.001*	F(2.48, 10, 261) = 0.01*	F(2.32, 8, 262) = 0.02*	F(0.05, 1, 261) = 0.82
2001/2002	F(3.29, 6, 265) = 0.01*	F(2.84, 7, 264) = 0.01*	F(2.18, 5, 265) = 0.06	F(0.23, 1, 264) = 0.63
2002/2003	F(1.36, 3, 236) = 0.26	F(1.18, 4, 235) = 0.32	F(1.47, 2, 236) = 0.23	F(0.75, 1, 269) = 0.39
2003/2004	F(0.98, 7, 264) = 0.45	F(1.09, 8, 263) = 0.37	F(0.77, 6, 267) = 0.59	F(1.85, 1, 263) = 0.17
2004/2005	F(0.45, 7, 264) = 0.87	F(0.51, 8, 263) = 0.85	F(0.11, 6, 267) = 0.99	F(0.95, 1, 263) = 0.33

*p < 0.05

Table 5. Association between the change in team quality and change in ranking corrected for positive team quality (d_qua_n=1) under the new coach using Somer's d_{vx} association statistic.

	Change in ranking (inc_rank)		
	Decreased/stayed equal	Increased	Total
Change in team quality (inc_qua)	N %	N %	N %
Decreased/stayed equal	2	0	2
	100.00%	0.00%	8.70%
Increased	3	18	21
	14.29%	85.71%	91.30%
Total	5	18	23
	21.74%	78.26%	100.00%

Table 6. Association between the change in team quality and change in ranking corrected for negative team quality (d_qua_n=0) under the new coach using Somer's d_{yx} association statistic.

	Change in ranking (inc_rank)		
	Decreased/stayed equal	Increased	Total
Change in team quality (inc_qua)	N %	N %	N %
Decreased/stayed equal	6	1	7
	85.71%	14.29%	31.82%
Increased	9	6	15
	60.00%	40.00%	68.18%
Total	15	7	22
	68.18%	31.82%	100.00%