Piecewise linear regression techniques to analyse the timing of head coach dismissals in Dutch soccer clubs

T. DE SCHRYVER[*]

School of Management and Governance, University of Twente, PO Box 217, 7500 AE Enschede, The Netherlands and Faculty of Social Sciences, Vrije Universiteit Amsterdam, De Boelelaan 1081, 1081 HV Amsterdam, The Netherlands
[*]Corresponding author: t.deschryver@utwente.nl

AND

R. N. EISINGA

Faculty of Social Sciences, Radboud Universiteit Nijmegen, PO Box 9104, 6500 HE Nijmegen, The Netherlands
r.eisinga@maw.ru.nl

The key question in research on dismissals of head coaches in sports clubs is not whether they should happen but when they will happen. This paper applies piecewise linear regression to advance our understanding of the timing of head coach dismissals. Essentially, the regression sacrifices degrees of freedom for increased possibilities of interpretation. In the empirical part, we show that badly performing clubs tend to wait for clear evidence before dismissing a head coach. Dutch soccer clubs only dismiss head coaches during the soccer season when a club loses a match it should not have. We also find that once the decision to dismiss the incumbent head coach has been made, clubs quickly tend to appoint a new one, possibly by attracting an interim coach.

Keywords: piecewise linear regression; timing; dismissal of head coaches; interpretation; soccer.

1. Introduction

In his keynote speech on the 2nd IMA International Conference on Mathematics in Sport, Jim Albert said that our ability to produce sports data goes beyond our ability to analyse them (see also Albert, 2009). Despite the opportunities for research in data rich sports industries, our understanding of especially organizational decision making in sports clubs has been progressing rather slowly (Wolfe *et al.*, 2005). Previous research has found out what kinds of decisions are typically made in sports clubs. For example, De Heij *et al.* (2006) classified the managerial decisions of European soccer clubs into six categories: 'player trade', 'coach trade', 'extension of player/coaches contracts', 'financial issues', 'structural changes' and 'stadium developments'. Unfortunately, we know little about when or why these decisions are being made.

To improve our understanding of the timing of decision making in clubs, this paper focusses on one of the six categories of De Heij *et al.* (2006), namely the decision to replace the head coach. Previous work has indicated that performance feedback from recent matches is an important precursor of head coach dismissal during the season (e.g. Audas *et al.*, 1999). The literature has, however, not ruled out whether the soccer club comes into immediate action after negative performance feedback. Soccer clubs

may decide to postpone the dismissal or to replace the head coach quickly. Reasons to postpone the dismissal of a head coach are the lack of available head coaches during the season, little guarantee that the replacement will bring about success and the financial costs involved in firing the incumbent head coach and attracting another one. Clubs may avoid these costs by postponing the dismissal and hope that substandard performance will be reversed in subsequent matches. Alternatively, when substandard performance is taken seriously, clubs may replace their head coach quickly. In order to lower the risks of such a decision, clubs may consider using short-term contracts. By means of an interim coach, clubs can break with the past and postpone serious commitments for the future. Making use of interim coaches is thus a clear indication of accelerated decision making.

Consequently, several authors have argued that the timing of the head coach dismissals is important to study (e.g. van Dalen, 1994; Hope, 2003). van Dalen (1994) argues that the uncertain benefits and the certain costs of changing head coaches during the season makes postponing a serious option as clubs can use the time to learn more about the substandard performance. He also argues that this option expires as time elapses. Waiting too long may result in too little time to turnaround the situation during the season. As a result, van Dalen (1994) argues that the ultimate timing of a head coach dismissal depends on the time preference of the club, which, in turn, is a function of the investments and the aspirations of the club. More specifically, he propounds that when performance drops below the aspirations, the decision to replace the head coach will be made.

This paper adds to van Dalen (1994) by empirically investigating the relationship between performance, aspirations and head coach dismissals. The methodology relies on a technique known as piecewise linear models. Piecewise linear regression has been applied in business (Greve, 2003) and in sports research (De Schryver & Eisinga, 2009).[1] Section 2 shows how piecewise linear regression models unravel the timing of head coach dismissal.

2. Piecewise linear models

Piecewise linear regression models are (generalized linear) multiple regression models that test whether a stimulus (S) triggers a similar response (Y) in different areas of S (Willett *et al.*, 1998). The relationship between S and Y is therefore broken into two or more pieces. The slopes between S and Y for each (broken) piece can be estimated and compared by means of standard regression techniques.

In this paper, the odds of head coach dismissals are taken as the response (Y). The stimulus (S) is related to match results. Although there is a continuous stream of information when clubs play their matches, not all match results contain relevant information for decision making. Relevant information only occurs when the sports result is not aspired (and/or expected) (Cyert & March, 1963; Greve, 2003). The stimulus for decision making (S) is thus a clear difference between the actual gain from a match result (P) and the aspired gain from a match result (L).

New information occurs when results are either much better than aspired or worse than aspired. Depending on the kind of information, it will instil feelings of success or feelings of failure. To discriminate between these possibilities, S is rewritten as $SD_{(P \leqslant L)} + SD_{(P > L)}$, with $D_{(P \leqslant L)} = 0$ if $P > L$ and 1 if $P \leqslant L$ and $D_{(P > L)} = 0$ if $P \leqslant L$ and 1 if $P > L$. The dummy variables $D_{(P \leqslant L)}$ and $D_{(P > L)}$ demark regions where feelings of success or failure are likely to occur. By multiplying the two dummy variables with the stimulus S, piecewise linear models separate the effects of above-standard performance

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[1]This paper is a revised and extended version of a paper presented at the 2nd International Conference on Mathematics in Sport. Compared to De Schryver & Eisinga (2009), the paper also reports the data collection and methodology procedures thereby increasing the possibilities for replication.

$(SD_{(P>L)})$ from substandard performance $(SD_{(P \leqslant L)})$. For example, when S is positive, there is no influence of $SD_{(P \leqslant L)}$ on Y because $D_{(P \leqslant L)}$ is 0. Instead, the effect of S on Y is sent through $D_{(P>L)} = 1$ to $SD_{(P>L)}$.

In Sections 2.1 and 2.2, we describe how this redundant model specification increases opportunities for interpretation. We start with the simplest case where there is a single stimulus and subsequently increase the number of stimuli. We will show that the possibilities for interpretation increase with the number of stimuli.

2.1 *Piecewise linear models for one stimulus*

In the most simple case, where there is only one stimulus, the linear predictor of the piecewise linear model is

$$\beta_0 + \beta_1(SD_{(P \leqslant L)}) + \beta_2(SD_{(P>L)}). \tag{1}$$

In contrast to a simple linear model specification, the piecewise linear model makes three scenarios explicit. Acknowledging that β_1 may be equal to β_2, that β_1 may be greater than β_2, or that β_2 may be greater than β_1, is at least important to management researchers as it is to know whether the relationship between the stimulus and the response is different from zero. Therefore, the hypothesis to be tested is

$$H_0: \beta_1 = \beta_2. \tag{2}$$

In the remainder of this section, we outline how each of the three scenarios needs to be interpreted. When β_1 equals β_2, a simple linear relationship between performance and the odds of replacing the head coach suffices. The linearity suggests that decision making goes smoothly. There is an automatic accommodation to the current state of organizational performance. A linear relationship indicates that it is business as usual. Shifts in performance do not lead to extra deliberation in the organization. The sign of the regression coefficient tells us when decisions are popular. For example, a negative relation indicates that above-standard performance stalls generally considered unpopular actions as much as substandard performance triggers these unpopular but necessary actions.

When there is some form of deliberation, we will observe a difference between β_1 and β_2. Delays in decision making typically occur when $\beta_2 < \beta_1 < 0$ (Greve, 2003). A negative relationship again indicates that head coach dismissals are unpopular actions that are only considered under performance pressure. The non-linearity indicates that there has been some hesitation. On the right-hand side of aspirations, the relationship is steep because there is neither a performance trigger from positive performance feedback nor intrinsic motivations to replace the head coach. On the left-hand side of aspiration, a head coach dismissal is only considered once there is enough support for the risk. The eroding resistance against the decision makes the relationship between performance and the odds of replacing the head coach negative but flatter on the left-hand side of aspirations than it is on the right-hand side.

Piecewise linear models can also highlight when the dismissal of the head coach has been speeded up. Two scenarios should be considered. First, $\beta_1 < \beta_2 < 0$ indicates that the replacement of the head coach becomes increasingly popular when already existing problems get worse. The odds of head coach dismissals moderately increase when problems start to occur; simply because many different solutions will be considered. At a certain point, there will be momentum to tackle problems by replacing the head coach, leading to a significant push in the number of head coach dismissals. During periods of success, it is common to assume that there is neither a performance trigger from positive performance feedback nor intrinsic motivations to replace head coaches. Second, $\beta_2 < 0$ and $\beta_1 > 0$ indicates that head coaches are quickly replaced when problems emerge. It suggests that the replacement of head coaches

is the preferred action when problems start to occur and that it is abandoned when problems persist. Again, during periods of success, there is neither a performance trigger from positive performance feedback nor intrinsic motivations to replace head coaches.

2.2   *Piecewise linear models for multiple stimuli*

While piecewise linear models could be fitted for one source of information, these models lack realism because sports clubs normally aspire many different things. For one, they want to stay in their league. They generally also aspire to do at least as good as the years before. In addition, they may aspire to do as good as their competitors (status-based performance). And top teams may aim for qualification to European tournaments. Because the management literature suggests that different stimuli will lead to differences in managerial decision making (Mezias *et al.*, 2002), we should consider a more complex model. Since there are many different aspiration levels, clubs receive different stimuli simultaneously following a match. This situation can be accommodated easily by piecewise linear regression models. For each aspiration, two extra variables need to be included into the model. A realistic model for head coach dismissals is therefore

$$\ln(\Pi/1 - \Pi) = \beta_0 + \sum \beta_{1ij}(S_{ij}D_{(Pij \leqslant Lij)}) + \sum \beta_{2ij}(S_{ij}D_{(Pij > Lij)}). \tag{3}$$

The model in Equation (3) uses a logit link function to relate the linear predictor to the odds of head coach dismissals ($\Pi/1 - \Pi$). The linear predictor assumes that (i) sources of information can be put in (j) different perspectives: (i) is thus the indicator of the source of information and (j) the indicator of the aspiration. In the empirical part of the paper, we have used the ranking of the club and the number of points obtained after a match as relevant sources of information ($P_{i=2}$). The number of points is compared to the number of points that could be expected from the last five match results, leading to the variable 'short-term performance'. The ranking of the club is compared to a weighted moving average of the final ranking over the last three years, leading to 'long-term performance'. The ranking is also compared to the minimum ranking that is necessary to attain next year's Champions League (CL) ('Ticket to CL') or UEFA tournament ('Ticket to UEFA') and the minimum ranking to remain in next year's premier league ('Ticket to premier league'). These five variables are split up into variables with a substandard ($-$) sign and variables with an above-standard ($+$) sign.

We do not expect that all five stimuli will be important antecedents of head coach dismissals because we know from psychology at large that human decision makers cannot attend to all stimuli simultaneously (Hertwig *et al.*, 2004). Even if clubs aspire different things, they can only attend a restricted number of signals simultaneously. Multiple signals make it less likely to find relationships between stimuli and head coach dismissals because clubs do not have to respond to signals immediately. One disappointing stimulus does not necessarily correspond to an urgent situation. As long as there are signals indicating that performance is above standard, a club can shift his attention to another reference point. Even though there are clear differences between the five stimuli, we currently do not know in advance which of the stimuli matter most. The differences between the five stimuli can be mapped on two dimensions. First, while short-term and long-term performance are backward-looking performance signals, the Tickets to CL, UEFA and premier league are forward-looking signals where selection mechanisms determine who will participate in future tournaments. Second, all signals save short-term performance consider the long term. The challenge is to find out where the attention of the clubs goes out to. We put forward Equation (3) as a way out. Since this model does not only reveal whether hastenings or delays occur in managerial decision making but also discriminates between different attention points, it facilitates a richer interpretation of managerial decision making after performance feedback.

Therefore, the hypotheses to be tested from Equation (3) are

$$H_0: \beta_{1ij} = \beta_{2ij} = 0. \tag{4}$$

3. Data and statistical methodology

We have applied Equation (3) to the head coach dismissals in the Dutch premier soccer league during the seasons 1990–2005. During the period of analysis, the Dutch premier soccer league is organized as a yearly recurring double round-robin tournament with 18 participating clubs. Due to relegation effects, 29 different clubs participated in the Dutch premier league in that period. We will analyse the decision to replace head coaches during the season and between seasons. In the within-season analysis, we focus on the stimuli that clubs received after each match played. In the between-season analysis, we focus on the stimuli that clubs received at the end of the season. The number of stimuli will be smaller than in the within-season analysis.

Data on the match results, the ranking and the head coaches were collected from home.wanadoo. nl/ronald.zwiers and compared for consistency with data from www.koningvoetbal.nl and www. voetbalnederland.nl. The aspirations were computed from the data, using insights from Greve (2003).

For the statistical analysis, the following methodological choices were made. First, the logistic models fitted the odds that the head coach is replaced. Since the use of interim coaches can be an important indicator for speeding up decision making, we made the distinction between interim replacements and full replacements within the season. This entailed fitting a multinomial logistic regression model for correlated responses. In order to use standard software, we have relied on Kuss & Mclerran (2007) who suggest rewriting the multinomial model into a bivariate binary model. This transformation will explain why the number of clusters is 576 (i.e. twice 288) in the within-season analysis.

Second, the serial correlation in the sample, due to the repeated measures of the same club, has been modelled by generalized estimating equations (GEE). The variance–covariance matrix V_y in GEE is specified by T, a positive diagonal matrix representing the variance of the theoretical distribution of Y and $R(\alpha)$, the working correlation matrix for the repeated measurements. With ø being a scalar, the true variance–covariance matrix $\mathbf{V}_y$ is then approximated by

$$V_y \approx \text{ø } T^{1/2} R(\alpha) T^{1/2}. \tag{5}$$

We have chosen GEE because it gives consistent estimates of $\boldsymbol{\beta}$ and of V_β, i.e. the empirical estimator of the variance–covariance matrix of $\boldsymbol{\beta}$, even if the researcher has misspecified $R(\alpha)$. GEE corrects for misspecification of $R(\alpha)$ given that the number of independent clusters is sufficiently large (Diggle et al., 2002, pp. 138–140). In the within-season analysis, the number of clusters is 576. The number of clusters can be easily reconstructed. We assume that clubs turn a page by selling and attracting new players at the end of the season. Therefore, we have taken for the within-season analysis, the club year as the independent cluster from which is being sampled. This assumption leads to 16 (years) x 18 (clubs in a league) = 288 club years with 34 repeated measures. Because the dependent variable in the multinomial logistic regression consists of three categories and one category of the dependent variable is chosen as the comparison category, we have to multiply the 288 club years by two to arrive at the number of clusters in a bivariate binary model. In the between-season analysis, where a simple logistic regression model for correlated responses is fitted, the number of clusters is only 29, with maximum 16 repeated measures. As a rule of thumb, we rely on Stokes et al. (2000, p. 479), who have suggested that about 200 clusters are needed to have sufficient confidence in the results of GEE estimation.

The minimum criterion was thus satisfied for the within-season analysis but not for the between-season analysis.

Finally, we have controlled for alternative explanations by adding confounding variables to Equation (3). In both the within-season and between-season analysis, we controlled for different time effects due to changes in institutional regulations and due to the increasing trend of commercialization in sports and also for reputation effects of the clubs; both nationally and internationally. In addition, in the within-season analysis, we controlled for match-specific factors, like home and away matches, matches in the beginning or at the end of the season. The full model specification is presented in De Schryver (2009, pp. 101–123) and is also available from the authors upon request.

4. Results

Piecewise linear models facilitate the interpretation in two ways. First, because they belong to the family of multiple regression models, it can be used to determine which subset of stimuli matters most for managerial decision making in soccer clubs. Second, they give insights into the timing and the drivers of head coach dismissals. In this section, we describe the results according to the two benefits.

We first determine which stimuli draw the attention of an average club in the Dutch premier league. The within-season analysis in Table 1 shows that historical performance indicators determine the dismissal of head coaches more than forward-looking performance indicators. The replacement of head coaches during the season is unrelated to concerns about future participation in tournaments. Even the threat of relegation does not lead to strong responses during the season. Clubs are more inclined to look backwards and to rely on constructed performance signals than to rely on signals about the future.

TABLE 1 *Piecewise linear model estimates for head coach dismissals*

Stimuli (S)	Odds of head coach dismissals	During the season				Between seasons			
		Estimates		Contrasts		Estimates		Contrasts	
		β	(p)	$\beta_1 - \beta_2$	(p)	β	(p)	$\beta_1 - \beta_2$	(p)
Short-term performance (−)	Full replacement	−0.25	(0.02)	0.11	(0.83)				
	Interim replacement	−0.46		−0.31	(0.55)				
Short-term performance (+)	Full replacement	−0.35	(0.56)						
	Interim replacement	−0.15							
Long-term performance (−)	Full replacement	0.32	(0.10)	0.21	(0.29)	0.09	(0.48)		
	Interim replacement	0.16		0.01	(0.97)				
Long-term performance (+)	Full replacement	0.11	(0.05)			−0.04	(0.67)		
	Interim replacement	0.15							
Ticket to UEFA (−)	Full replacement	−0.05	(0.71)			0.23	(0.59)		
	Interim replacement	−0.21							
Ticket to UEFA (+)	Full replacement	−0.01	(0.35)			0.37	(0.38)		
	Interim replacement	−0.50							
Ticket to CL (−)	Full replacement					0.03	(0.92)	1.93	(0.00)
Ticket to CL (+)	Full replacement					−1.91	(0.01)		
Ticket to premier league (−)	Full replacement	0.21	(0.77)			−0.11	(0.84)		
	Interim replacement	0.08							
Ticket to premier league (+)	Full replacement	0.11	(0.56)			−0.36	(0.49)		
	Interim replacement	0.25							
Number of clusters		576				29			
Maximum cluster size		34				16			

Between seasons, the situation is reversed. The decision to replace a head coach between seasons depends on whether or not the club is able to play qualifying games for the CL.

We now turn to the timing and the motives for managerial decision making. In the within-season analysis, we find that when clubs receive relevant new information that they sometimes speed up decision making and sometimes quite naturally accommodate to new situations. In term of speeding up, there is statistical evidence that the short-term performance signal is treated different after failure than after success. Table 1 shows that only substandard short-term performance has a significant impact on the odds of head coach dismissals. The effect of above-standard short-term performance is not significantly different from zero. Since $\beta_1 < \beta_2 = 0$ for short-term performance in the within-season column of Table 1, we find evidence that head coaches are replaced when they loose matches they should not have lost. Clubs make use of the discontentment of the moment to replace the head coach. Moreover, when the distinction is made between full replacements and replacements by means of an interim coach, we get additional evidence that head coach dismissals are speeded up. The analysis suggests that the odds are highest that incumbent head coaches will be replaced by interim coaches after that clubs have lost matches they normally do not loose. The piecewise linear model in Table 1 thus suggests that there was special deliberation in the clubs after these matches.

This is not the case for the second backward-looking performance signal, long-term performance, even though it also affects the odds of replacing the head coach during the season. The results show that the odds of head coach dismissals increase when the ranking gets better than expected. This result is counterintuitive but it is also found by ter Weel (2006) in his analysis of a similar sample of head coach dismissals in the Dutch premier soccer league. It seems that clubs contain problems well before problems spread out. Head coaches will already have been replaced before the ranking drops below historical levels. The piecewise linear model additionally shows that replacing head coaches is common practice, which does not instil strategic timing because β_1 and β_2 are both positive and significant and not significantly different from each other. Especially, the use of interim coaches seems to be decided easily. Although there is a sample difference between full replacements and interim replacements, Wald statistics fail to find statistical support for differences between success and failure in both cases. There is thus evidence that a club does not behave differently when faced with sub- or above-standard rankings.

Finally, we find that not only the stimuli but also the motives for replacing head coaches between seasons seem to be different from the within-season case. In the between-season analysis, we compared the name of the head coach at the end of the soccer season with the name of the head coach at the start of the next soccer season and regressed between-season dismissals on performance signals derived from the final ranking at the end of the season. We find that the attainment of tickets for the CL qualifying tournaments is important to Dutch soccer clubs. The piecewise linear model in Table 1 reveals more. Since $\beta_2 < 0 = \beta_1$, for Ticket to CL in the between-season column of Table 1, there are different attributions for extreme success versus failure between seasons. It makes a difference whether or not clubs are playing the qualifying rounds of the CL. A comparison of the coefficients reveals that clubs being able to attain a ticket to the CL try to retain the incumbent head coach. This kind of extreme success lowers the odds of between-season dismissals to $0.14 = (e^{-1.91})$. This result may be related to the fact that clubs already have to play qualifying games for the CL at the beginning of the season. There is therefore no time to experiment at the start of the season.

5. Conclusions

By means of piecewise linear models, we have provided new insights into the managerial decision-making process in soccer clubs. The analyses suggest that clubs carefully select information and shift

attention according to the state in which the tournaments operate. Within season, clubs are only eager to replace head coaches after matches that they normally should have won. We have shown that head coaches have to deliver a level of performance that is comparable to past performance during the season in order to avoid being replaced. Once performance falls below historical aspirations, decisions to replace the head coach are executed quickly, often by means of interim coaches. We also found that clubs retain highly successful head coaches between seasons. This may be due to the fact that clubs have to play qualifying games for the Champions League early on. We speculate that clubs try to prepare themselves ideally for the knock-out qualifying rounds at the start of the season. There is no time for these clubs to experiment. The main contribution of this study was to show that piecewise linear models contribute to a better understanding of decision-making processes after performance feedback by focussing on the timing of the decisions. Difficult decisions like head coach dismissals are often made in turbulent times. Consequently, they are often fraught with speculations. Piecewise linear models give researchers a tool to understand the fuzzy decision-making processes better.

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