Some Determinants of the Natural Level of Competitive Balance in European Football and US Team Sports: The Role of the Referee, the Scoring Context and Overtime.

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Abstract:
In this paper, some unique characteristics of European football are identified and modelled which have in common that they have a conducive effect on the competitive balance. First, it is shown that the rather low average number of goals per match in football as opposed to say basketball has a strong beneficial effect on the level of competitive balance. Second, all other things equal, an impartial but highly erratic referee also has a positive effect on the level of competitive balance. This is relevant for the current discussion whether or not the referee should be assisted by a fifth official equipped with a monitor to eliminate the most blatant mistakes in refereeing. Third, the high frequency that games end in ties in European football also raises the natural level of competitive balance. These phenomena may explain why in US sports highly artificial measures (e.g. rookie draft, gate revenue sharing, special exemptions from antitrust law) are in force to maintain competitive balance, which are absent and unnecessary in European football.

1 Introduction

The need to maintain CB has been used by sports league associations, notably in the USA, to derogate on antitrust law. Usually, these exemptions from regular antitrust law are justified by the claim that special measures – such as the rookie draft pick, revenue sharing, reserve clauses, and salary and payroll caps – are necessary to increase, or at least to maintain, CB.¹ In my view, the need for such measures is much less for European football. I will argue that a number of factors inherent in European football but largely absent in typical American team sports, raise the natural level of CB. First, football is characterized by a low scoring context, opposed to the high scoring contexts of American sports, notably basketball. It is demonstrated that, ceteris paribus, CB increases sharply if the average number of goals per game decreases. Second, an impartial referee making mistakes has a beneficial effect on the degree of CB. Consequently, measures helping referees to make the right decision, such as more referees or the introduction of a fifth official with a TV monitor and a head-set connection to the referee, will decrease CB. An erratic referee expands the role of chance hence reduces the role of skills in the outcome of a match. A highly erratic referee can be seen as an important supplier of additional ‘noise’ in an

¹ For more details about the relevance of CB in sports, see e.g. Szymanski (2001; 2003; 2005) and Szymanski and Kesenne (2004).
otherwise probabilistic process. Note that in typical American sports, e.g. baseball, basketball, American football, there are more referees per number of athletes entering the pitch than in European football. Apparently, Americans prefer a greater role for skills at the expense of chance in the determination of the outcome of a contest.²

Third, the possibility of ties opposed to the practice of overtime in US sports to single out a winner also raises CB. On top of that, the optimal level of CB in the open leagues of European football is lower than in the closed American leagues due to the practice of promotion and relegation. A major disadvantage of a higher level of CB in an open league is the higher chance that strong drawing teams are relegated. In a closed league this cannot occur so, all other things equal, the optimal level of CB is higher in a closed than in an open league.

Taking stock, comparatively there are some factors that result in a higher natural level of CB in European football, while at the same time the optimal level has to be lower than in closed American leagues. Henceforth, the burden of evidence for European football to obtain special exemptions from antitrust law in order to maintain CB is much higher than for American sports. Phrased differently, the reliance on exceptionally strong artificial intervention measures in American sports to maintain CB can be explained by the fact that most American sports, compared to European football, are characterized by high scoring contexts, more perfect refereeing and the practice of overtime following a tie in regular time, all lowering the level of CB while the optimal level needs to be higher. As will become clear from the analysis of section 2, the highly artificial measures in US sports to maintain a sufficient degree of CB can largely be explained by the relatively high scoring contexts of these sports: the higher the average number of goals per match, the more small differences in team qualities will result in large differences in winning performances, that is, a lower natural level of CB. If I am right, the higher the scoring context of a sport, the more drastic and artificial the intervention measures must be to maintain a healthy degree of CB. For instance, according to this hypothesis basketball will have stronger measures to intervene than baseball, which in turn has stronger measures than European football.

2 Competitive Balance and the Scoring Context

In this paper, goal scoring is modelled as a Poisson process, where the scoring of a goal in a contest is referred to as an event. Characteristic of a Poisson process is that the occurrence of an event is (i) rare, (ii) random and (iii) unrelated to the occurrence of previous events. Seasoned fans may doubt whether all these conditions are met, but I think for the purposes of this analysis it is seen to be ‘Poisson enough’. Let \( Y \) be the variable representing the number of goals scored in a match by a team, which can take on the values 0, 1, 2, 3, ..., then

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² E.g. in baseball, there is a special referee for the first base, only to check whether the hitter is in or out. Since American sports have a higher number of goals per match, the effect of better refereeing on the outcome is less than in the low scoring context of European football: in a low (high) scoring context, the effect of a single mistake by the referee on the final outcome is large (small). In higher scoring context, it is also more likely that mistakes cancel out against each other, as long as the referee is impartial. Therefore, one would expect a greater demand for better refereeing in low scoring context sports, but in practice we see the opposite: the intensity of refereeing, measured by the number of referees and the usage of monitors and replays, is much higher in the high scoring context American team sports.
Thus, the Poisson distribution of goal scoring can be defined in terms of a single parameter $\mu$, which reflects the propensity to score goals. If two teams enter the pitch, there is a Competing Poisson process and two parameters $\mu$ and $\nu$ are required: the propensity to score goals and the propensity to concede goals, where the latter is of course equal to the scoring propensity of the other team. The chance on outcome $(x, y)$ is simply $P(X=x) \times P(Y=y)$. The symbol $r$ is used to denote the relative strength of team A versus B, so $\mu = r \nu$. For instance, $r = 0.5$ implies that team B’s scoring propensity is twice as great as A’s. To express the scoring context, that is, the average number of goals per match, we use the symbol $s$, and $\mu + \nu = s$. The scoring context may differ per sport, e.g. in basketball $s$ is much higher than in football.

In this section, the impact of the scoring context on the expected winning equivalent probabilities is analyzed, where the winning equivalent is calculated as one match point for a win and a half point for a draw (in what follows, it is assumed that the 2-1-0 convention is followed, with one league point for a draw and two for a victory). Given the relative strength $r$ of two teams A and B in terms of scoring propensities and the scoring context represented by the variable $s$, we have:

$$\mu + \nu = s$$
$$\mu = r \nu \quad 0 < r < 1$$

with $\mu$ ($\nu$) the scoring propensity of team A (B). $0 < r < 1$ implies that A is the weaker team. Figure 1 gives the winning equivalent probabilities when $s$ varies from 0 to 100. Of course, if the average total goals per match is zero, all games must end in draws and the winning equivalent probabilities are by definition 0.5. Moreover, since the winning equivalent probabilities of A and B together must sum to unity, the line of winning equivalent probabilities of team B is the mirror image of the line belonging to A, with the line $WE = 0.5$ as the mirror. In Figure 1, three lines are drawn, corresponding to $r$ set equal to 0.1 ($r_l$), 0.5 and 0.9 ($r_h$) respectively. For $r = 0.1$, B’s scoring propensity is ten fold that of A. As a consequence, if the average total goals per match increases, the winning equivalent probability of A drops sharply because A’s expected share in a marginal increase in the number of goals per match is only 9 percent, against 91 per cent for B.

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3 Suppose the strength of team A is given by $\mu^A$ (represented by the average number of goals per match scored for) and its weakness by $\nu^A$ (average number of goals conceded per match). With only two teams, by definition $\mu^A = \nu^B$ and $\nu^A = \mu^B$, so it is more convenient to use only $\mu$ and $\nu$. 

$$P(Y = y) = \frac{e^{-\mu} \mu^y}{y!}$$
Figure 1. The winning equivalent depending on relative scoring propensities and scoring context.

To isolate the effect of a different scoring context on the competitive balance (henceforth CB) of two sports, say basketball and football, the relative team qualities must be kept constant. Basketball has a scoring context of close to 100 goals per match and soccer of less than 3 goals per match. As can be seen from Figure 1, if $r = 0.9$, the chance of the weaker team A to win is still 46.5 per cent in football, but only 20 per cent in basketball. Therefore, the same relative team (ine)qualities (or inequalities in wage expenditures on talent) give a much lower level of CB in high scoring context sports, which explains why the typical high scoring context American sports have to take drastic and often highly artificial measures to maintain CB.

The above is schematically illustrated in Figure 2. $\mu$ and $v$ are on the vertical and horizontal axes, respectively. Three perpendicular iso-scoring context lines are drawn: $s = 1$, $s = 3$ and $s = 10$. The 45°-line from the origin, orthogonal to these iso-scoring context lines, represents the iso-winning equivalent line with an winning equivalent equal to 0.5, since on the 45°-line $\mu = v$, so both teams are equal. CB at this line is at maximum and perfect.

Using the Competing Poisson process, for $s = 3$ and $r = 0.5$ (so $\mu = 1$ and $v = 2$), it can be calculated that the winning equivalent for team A is 0.288 (or a winning percentage of 28.8 percent). The bold curved line is the iso-winning equivalent line that goes through this point $\mu = 1; v = 2$. The (tangent of the) angle of the ray from the origin to this point represents $r$, which is equal to 0.5. To get the same winning equivalent of 0.288 for a scoring context of 1, it can be calculated that $\mu = 0.177$ and $v = 0.823$, so $r = 0.215$; for $s = 10$, $\mu = 4.125$ and $v = 5.875$, so $r = 0.7$; for $s = 100$, $\mu = 49.5$ and $v = 51.5$, so $r = 0.98$. Figure 2 illustrates that in order to stay on the iso-

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4 Note that one advantage of the Competing Poisson process of goals scoring compared to logit contest functions is that the scoring context can be included. The parameters $\mu$ and $v$ determine $s$ as well as the winning percentage. Under a logit contest function, only relative team qualities enter the formula, with no relation to the scoring context.
winning equivalent line – that is, to maintain the same level of CB – while increasing the scoring context requires a steadily increasing value for $r$, where $r$, defined as the ratio of $\mu$ and $v$, stands for relative team qualities. In the limit, to maintain a non-negligible level of CB in an extremely high scoring context, relative team qualities must be nearly equal. In other words, special measures to maintain CB are stronger, the higher the scoring context, so in basketball more intervention from governing bodies can be expected than in baseball, and in turn more in baseball than in football. The importance of the scoring context for the level of CB in sports is so large that I am inclined to think that also in for instance professional tennis the natural level of CB is extremely low. The low level that remains is largely due to players having offdays or being in top condition, different performance on clay courts than on grass courts, the rise and decline of players over time, the lack of transivity (if A wins from B and B from C, it does not follow that A wins from C) and the effect that one can win a match despite have won fewer points or games than the opponent.

![Figure 2. Iso-winning curve, iso-scoring lines and relative team qualities.](image)

3 Competitive Balance and the Role of the Referee

The Poisson distribution can also be used to show that, all other things equal, an impartial but fallible referee is conducive to CB, that is, the winning equivalent for the weaker team is smaller under a perfect referee than under a referee making at random mistakes. Intuitively, a referee making at random errors produces noise that disturbs
the outcome of the match towards a more balanced outcome than would be the case where the outcome is only determined by relative team qualities.

Under a perfect referee (PR), the winning equivalent for team A ($WE^{PR}_A$) is:

\[
(1) \quad WE^{PR}_A = \frac{1}{2} P(A = B) + P(A > B) = \frac{1}{2} P(A = B) + [1 - P(A \leq B)] = \frac{1}{2} P(A = B) + [1 - P(A < B) - P(A = B)] = 1 - P(A < B) - \frac{1}{2} P(A = B)
\]

where for convenience the number of goals scored by team A is denoted by $A$.

Suppose that under a fallible but impartial referee (IR), at random either one goal is granted to A or to B. If the referee is deciding in favour of A, then:

\[
(2) \quad WE^{IR_A}_A = \frac{1}{2} P(A + 1 = B) + P(A + 1 > B) = \frac{1}{2} P(A + 1 = B) + [1 - P(A + 1 \leq B)] = \frac{1}{2} P(A + 1 = B) + [1 - P(A + 1 < B) - P(A + 1 = B)] = 1 - P(A + 1 < B) - \frac{1}{2} P(A + 1 = B)
\]

and if in favour of B, then:

\[
(3) \quad WE^{IR_B}_A = \frac{1}{2} P(A = B + 1) + P(A > B + 1) = \frac{1}{2} P(A = B + 1) + [1 - P(A \leq B + 1)] = \frac{1}{2} P(A = B + 1) + [1 - P(A < B + 1) - P(A = B + 1)] = 1 - P(A < B + 1) - \frac{1}{2} P(A = B + 1)
\]

\[
\begin{array}{cccccc}
A \downarrow B & \rightarrow & 0 & 1 & 2 & 3 & 4 & 5 \\
\hline
0 & X & X & X & X & X & & \\
1 & & X & X & X & X & & \\
2 & & & X & X & X & & \\
3 & & & & X & X & & \\
4 & & & & & X & & \\
5 & & & & & & &
\end{array}
\]

\[
\begin{array}{ccccccc}
A \downarrow B + 1 & \rightarrow & 1 & 2 & 3 & 4 & 5 & 6 \\
\hline
0 & X & X & X & X & X & X & & \\
1 & & X & X & X & X & X & & \\
2 & & & X & X & X & X & & \\
3 & & & & X & X & X & & \\
4 & & & & & X & X & & \\
5 & & & & & & X & & \\
\end{array}
\]

\[
\begin{array}{cccccc}
A + 1 \downarrow B & \rightarrow & 0 & 1 & 2 & 3 & 4 & 5 \\
\hline
1 & X & X & X & X & & & \\
2 & & X & X & X & & & \\
3 & & & X & X & & & \\
4 & & & & X & & & \\
5 & & & & & & & \\
6 & & & & & & &
\end{array}
\]

Table 1. Outcomes where A is losing against B (market by X) under a perfect referee, a fallible referee granting one extra goal in favour of B, or one in favour of A.

From the tables it follows that:
\[(4a) \quad P(A < B) = P(A + 1 < B) + P(A = B + 1); \]
\[(4b) \quad P(A < B + 1) = P(A < B) + P(A = B) \]

Since under a fallible but impartial referee both situations are equally likely to occur, using Eqs. (4), the expected advantage per match \((\Delta^R)\) for the weaker team A can be expressed as:

\[(5) \quad \Delta^R = \frac{1}{2} WE_A^{IR} + \frac{1}{2} WE_A^{BR} - WE_A^R =
\]
\[
\frac{1}{2} [1 - P(A + 1 < B) - \frac{1}{2} P(A + 1 = B)] + \frac{1}{2} [1 - P(A < B + 1) - \frac{1}{2} P(A = B + 1)] - [1 - P(A < B) - \frac{1}{2} P(A = B)] =
\]
\[
P(A < B) + \frac{1}{2} P(A = B) - \frac{1}{2} P(A + 1 < B) - \frac{1}{2} P(A + 1 = B) - \frac{1}{2} P(A < B + 1) - \frac{1}{2} P(A = B + 1) =
\]
\[
\frac{1}{2} [P(A + 1 = B) - P(A = B + 1)]
\]

Since we have assumed that A is the weaker team, the chance that A with one extra goal draws against B will be higher than the chance that A draws against B with B given one extra goal, so it must be that \(\Delta > 0\), that is, an impartial fallible referee raises the expected winning equivalent of the weaker team compared to a perfect referee. Intuitively, an erratic referee allowing at random one irregular goal only makes a difference if otherwise team A would have lost by one goal or when team A would have won by one goal, but now draws. The chance of the former is higher than the latter, so an erratic referee is to the advantage of the weaker team.

To get an idea how large this effect is, a simulation is done (see Appendix A). Naturally, the higher the scoring context, the smaller the impact of an imperfect referee on the winning equivalent probabilities: if the number of goals is low, a single at random faulty decision of the referee (e.g. an unjust penalty due to a Schwalbe) will have a larger effect on the winning probability compared to when the number of goals is high. Again with \(\mu\) the propensity of team A to score goals and \(\nu\) the propensity of team B to score goals and \(\mu + \nu = 2.5\) to fix the scoring context, Figure 3 shows the winning equivalent probabilities plotted against the ratio \(\mu/\nu\) under both perfect and imperfect refereeing. The figure shows that an impartial fallible referee is to the advantage of the weaker team (the dashed line is always above the other line), so the introduction of a fifth official with a headset-connection to the referee will have the effect of a lower overall level of CB in a league. If referees tend to be ‘homers’ – deciding on average in favour of the team playing at home – then the effect of the fallible referee is likewise the home advantage effect (for the home advantage effect on CB, see Appendix B). Only if referees are on balance favouring the stronger teams, the introduction of a fifth official with a monitor might improve the level of CB.
4 Overtime versus ties

In this section it is investigated whether or not the possibility of games ending in ties, all other things equal, is conducive to CB. In European league football, a tie is a normal and highly frequent outcome because of the low scoring context. In US team sports, games ending in a tie in the regular time are followed by overtime. Through overtime, the few games that ultimately end in a tie position is reduced further. Here again, as with the referees, actual practice is opposite to what one would expect: in the US team sports with a high scoring context, the chance of a tie is very low, so there is little need for allowing overtime in regular season games, while in European football with a low scoring context, ties are ubiquitous and overtime would have a real function. In this section it will be shown that overtime, all other things equal, reduces the level of CB.

First of all, the probability of a tie decreases (i) the higher the scoring context and (ii) the larger the relative team inequalities. However, we are not so much interested in the frequency of ties, but rather in the effect of ties versus allowing extra time (and eventually shoot outs) to rule out ties on the expected winning equivalent for the weaker team. The winning equivalent for the weaker team A under the practice of ties is:

\[ WE^{tie} = P_{winR} + \frac{Ptie}{2} \]

with \( P_{winR} \) the probability of a win for A in the regular time. The winning equivalent under overtime (OT) can be expressed as:

\[ WE^{OT} = P_{winR} + Ptie(P_{winOT} + PtieOT/2) \]
The overtime can end in a win for A, a loss, or again in a tie. Assume for simplicity that under the practice of overtime, a game that ends in a tie in regular time is replayed in full. For the replay, the Poisson scoring parameters do not change and therefore $P_{\text{winOT}}$ is equal to $P_{\text{winR}}$ and $P_{\text{tie}}$ is equal to $P_{\text{tieOT}}$. The difference in winning equivalents can then be written as:

$$\Delta = WE^{tie} - WE^{OT} = P_{\text{tie}}(P_{\text{loss}} - P_{\text{win}})/2 > 0$$

since for the weaker team, $P_{\text{loss}}$ is higher than $P_{\text{win}}$. The weaker a team is, the higher the difference between $P_{\text{loss}}$ and $P_{\text{win}}$, but also the lower the chance of a tie. In addition, the difference between both practices is dependent on the incidence of ties, which is largely dependent on the scoring context. In football, ties are a normal phenomenon, because the scoring context is so low, whereas in most US sports, ties are rare. Because the probability of ties is much higher in European football, this implies that with the same relative team qualities, the negative effect of allowing overtime on CB is higher in football than in high scoring US team sports.

5 Competitive Balance and the Scoring Context over the past Century in English football

Probably the most important feature of football contributing to CB is the quite low average number of goals scored per match compared to other team sports such as basketball, volleyball, baseball, football and rugby. Figure 4 shows the development of the average number of total goals per match ($g_t$), the average number of goals per match scored by the home team ($g_h$) and the average number of goals per match scored by the away team ($g_a$) for the period 1888–2006 in England’s highest division. Over the entire period, on average 1.87 goals were scored by the team playing at home, 1.18 by the away team and in total 3.05 goals per match. The values for intercept and slope of the trend lines are:

$$g_h = 2.2742 - 0.0075t$$
$$g_a = 1.2721 - 0.0018t$$
$$g_t = 3.5464 - 0.0093t$$

where $t$ stands for years, starting with 1 for the first season 1888–89 and ending with 107 for the season 2005–06. Note that the trend line for $g_t$ is the sum of the other two. Interestingly, more than 80 per cent (0.0075/0.0093) of the gradual decline in the total number of goals scored can be attributed to the gradual decline in goals scored by the home team, which is more than expected given the share of 61 per cent (1.87/3.05) of the average number of goals scored by the home team in the average of total goals per match.
The gradual decline in goals per match amounts to 107 times \(-0.0093\), which corresponds approximately to a decline of one goal per match, from 3.55 to 2.55. As Ryder (2004a: 7; 2004b: 16–17) has shown, a higher scoring context gives a better winning ‘resolution’, while in a low scoring context, a superior team suffers more ties and losses due to bad luck than in a high scoring context. A simple example using the scoring context of soccer and ice-hockey may serve to prove this point.

Suppose we have two teams, whose relative strengths are fixed, say team A’s scoring propensity is twice as great team B’s. In soccer (in what follows denoted by subscript s) and ice-hockey (denoted by subscript h), the scoring context can be expressed as the average total number of goals per game, equal to \(g_s\) and \(g_h\), where \(g_s = 0.50 \times g_h = 3\) (note that this is quite a good approximation of the average total goals per match of 3.05 over the entire period 1888–2006). Assume scoring in soccer and hockey can be modelled as a Poisson process, where the strength and weakness of a team is given by the average number of goals scored for (\(\mu\)) and goals conceded (\(\nu\)) per match and with two teams, by definition \(\mu_A = \nu_B\) and \(\nu_A = \mu_B\). If team A’s scoring propensity is twice as great as B’s, then \(\mu_A = 2\nu_A\). To express the different scoring context, we have for soccer \(\mu_{A,s} + \nu_{A,s} = 3\) and for hockey \(\mu_{A,h} + \nu_{A,h} = 6\). The probability of a win by A in soccer is equal to 0.606 while in hockey it is 0.727, so 12 percentage points higher. The same phenomenon explains why in extremely high scoring contexts like basketball the top teams have extremely high winning percentages.

The intuition behind this result – a higher scoring context gives a higher resolution of the mapping of differences in team qualities into winning percentages – can be made clear by the experiment of tossing an unfair coin where, for example, the chance of tails is 40 per cent and of heads, 60 per cent. If the coin is tossed only once, corresponding to only one goal per match, the chance of more tails than heads (i.e. a win by the weaker team) is 40 per cent, but if it is tossed say a hundred times (hundred goals per match), the chance of more tails than heads is only 2 per cent. So equal levels of CB (e.g. when CB is measured by the standard deviation in win percentages) in sports with strongly different scoring contexts, say football and basketball, requires that the distribution of Poisson parameters across teams within a league with a higher scoring context is more close than in the other. In other words, the empirical finding that NBA basketball is more unbalanced than other typical American team sports is not surprising – taking into account the extremely high scoring context of basketball – and it does not imply that differences in team qualities
in NBA basketball are greater than in the other sports. The point is that in a high scoring context the resolution is high: even small differences in quality result in large differences in winning percentages. Going one step further, it is plausible that reliance on exceptionally strong intervention measures in American sports to maintain CB can be explained by the fact that most American sports, compared to European football, are characterized by high scoring contexts and hence a low level of CB in the absence of these measures.

What we want to know is what the CB would have been if the scoring context had not changed over time during the period 1888–2006. This decline is the net effect of the decrease in CB due to diverging team qualities and the increase in CB due to a decline in scoring context from 3.55 to 2.55. The point is that if, hypothetically, the scoring context had been constant at 3.55 over the entire period, then the decline in CB would have been larger and so the present level of CB even lower.

To calculate the counterfactual CB under a constant scoring scenario requires some more detail. Suppose we have a league of \( N \) teams, where each team is characterized by \( \mu_i = g_{fi} \) and \( \nu_i = g_{ai} \), where \( g_{fi} \) and \( g_{ai} \) stand for goals scored for and goals against per game of team \( i \). For high ranked teams, \( \mu_i = g_{fi} > \nu_i = g_{ai} \) and for low ranked teams vice versa. In state 0 – resembling the start of the period 1888–2006 – the average goals per game are set equal to \( g_f = g_a = 3.55 \) and in state 1 – resembling the end of the period 1888–2006 (see the trend line for the average number of total goals per match in Figure 4) – it is set equal to 2.55. To make it simple, we focus on the CB index as measured by the concentration ratio for the top 3 in each season. The concentration ratio \( C_j \) is defined as the actual number of league points (\( P \)), two for a win and one for a draw, collected by the top \( j \) teams divided by the maximum number of points they could have won:

\[
C_j = \frac{P}{2j(2N - j - 1)}
\]

In a competition completely out of balance, \( C_j \) is equal to 1 for all \( j \). In a perfectly balanced competition \( C_j \) is equal to \((N-1)/(2(N-2))\), which for large \( N \) tends to its lower boundary of 0.5. \( C_j \) can be transformed into \( C^*_j \) so that it varies between zero (perfectly unbalanced) and one (perfectly balanced):

\[
C^*_j = \frac{2(N - 2)}{(N - 3)}(1 - C_j)
\]

so

\[
P = 2j(2N - j - 1)[1 - \frac{(N - 3)C^*_j}{2(N - 2)}]
\]

Figure 5 shows the development of the \( C_3^* \) index over time, plotted against the \( STD^* \) (the correlation coefficient between them is 0.91).
The equation for the estimated trend line, based on the scores of the top 3 in all seasons, is $C_3^* = -0.0013t + 0.7015$, indicating a gradual decline of $107\times 0.0013 = 0.139$ or 13.8 percentage points ($t$ stands for time here). This trend line is taken as the point of departure for the following exercise. The first year (1888) on the trend line is taken as state 0, the last year (2006) taken as state 1. In between state 0 and state 1 there was a change in scoring context, from 3.55 to 2.55. For both states we know the $C_3^*$ trend line values. Each value of $C_3^*$ corresponds to a specific set of winning percentages for the top–3 teams. The winning percentage together with a specification of the scoring context determines the unique values of $\mu_i$ and $\nu_i$ for each state (note that we are using the Poisson process of goal scoring here). This line of thought is represented under the heading *Empirical* in Table 2. Next, under the heading *Hypothetical*, the procedure is reversed. We start with the $\mu_i$ and $\nu_i$ for one state and calculate the hypothetical winning percentages and $C_3^*$ values if the scoring context of the other state applies.

Table 2. Reconstruction of the level of CB in different scoring contexts

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Procedure</th>
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<tbody>
<tr>
<td>State 0 (1888)</td>
<td>$C_3^* \rightarrow w_i + (\mu_{i,0} + \nu_{i,0} = 3.55) \rightarrow \mu_0, \nu_0$</td>
</tr>
<tr>
<td>State 1 (2006)</td>
<td>$C_3^* \rightarrow w_i + (\mu_{i,1} + \nu_{i,1} = 2.55) \rightarrow \mu_1, \nu_1$</td>
</tr>
</tbody>
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<table>
<thead>
<tr>
<th>Hypothetical</th>
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</thead>
<tbody>
<tr>
<td>Relative team qualities 2006, scoring context 1888</td>
</tr>
<tr>
<td>Relative team qualities 1888, scoring context 2006</td>
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</tbody>
</table>

In state 0, at the start of the period 1888–2006 (fill in $t = 0$ in the trend line equation), $C_3^* = 0.7015$. Using Eq. (3), total league points collected by the top 3 teams is $P = 144.45$, which is equal to 48.15 per team, and the win percentage ($N = 20$ is assumed throughout) is $48.15 / (4(N-1)) = 0.633$ or 63.3 per cent. Because the $C_j^*$ index is indiscriminate as to how the points are distributed between the $j$ teams, with no loss we can assume that they are identical in winning percentage. We have so to speak three 0.633 teams at the top. The problem then is to find the Poisson process parameters $\mu_i$ and $\nu_i$ for which a 0.633 team quality applies and $\mu_i + \nu_i = 3.55$ for $i =$
1, 2, 3. A simulation in Excel gives the values $\mu_i = 2.107$ and $\nu_i = 1.443$. This is the calculation to be done on the first line of Table 2.

We now go to the second line of Table 2. For state 1 we have $C_3^* = -0.0013 \times 107 + 0.7015 = 0.5624$, so $P = 158.64$, so per team 52.88, so the win percentage is 0.696 or 69.6 per cent. The Poisson process with $\mu_i$ and $\nu_i$ which delivers three 0.696 teams and $\mu_i + \nu_i = 2.55$ applies gives the values $\mu_i = 1.705$ and $\nu_i = 0.845$. These empirical outcomes are used as inputs in the exercise of calculating the hypothetical values of $C_3^*$ (see rows three and four). For the third row, fix the ratio of the latter $\mu_i$ and $\nu_i$ (equal to 2.01775). To know what the concentration ratio would have been in state 1 under an unchanged scoring context (that of state 0), apply the additional restriction that $\mu_i + \nu_i = 3.55$. This gives $\mu_i = 2.374$ and $\nu_i = 1.176$. This corresponds to a win percentage of 73.2157, so 55.64 per team, so $P = 166.93$, so $C_3^* = 0.4811$. For the fourth row, use the values of $\mu_i$ and $\nu_i$ in state 0, fix its ratio and combine it with the scoring context of state 1. Table 4 gives a schematic overview.

Table 4. The concentration ratio as measure of CB, dependent on scoring context and relative team qualities

<table>
<thead>
<tr>
<th>C3* as measure for the degree of CB</th>
<th>Scoring context</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relative team qualities</td>
<td>1888</td>
</tr>
<tr>
<td></td>
<td>1888</td>
</tr>
<tr>
<td></td>
<td>70.15%</td>
</tr>
<tr>
<td>2006</td>
<td>48.11%</td>
</tr>
</tbody>
</table>

On balance then, the CB index as measured by the concentration ratio can be seen to have declined over the period 1888–2006 from 0.7015 to 0.5624, despite the gradual decline in the scoring context which, by itself, exerts an upward effect on the degree of CB. If the scoring context had stayed constant at 3.55 goals per game, the suggestion then is that CB would have declined to 0.4811. The decline due to diverging team qualities was therefore $0.7015 - 0.4811 = 0.2204$ or 22 percentage points instead of the superficial $0.7015 - 0.5624 = 0.1391$ or 13.9 per cent. This, in turn, implies that a considerable part of the negative effect of widening team qualities is not directly visible from the actual figures. In other words, by neglecting the gradual change in scoring context, the decline in CB due to widening team qualities is underestimated by more than 8 percentage points! Alternatively stated, almost 37 per cent (8/22) of the decline in CB is compensated by the positive effect on CB of the decline in the scoring context.

This analysis of the scoring context has a number of far-reaching implications. First, the relation between scoring context and CB can be put in the following testable proposition: the decline in the average number of goals is caused by the decline in CB. Weaker teams search for tactics that reduce the number of goals in order to raise their probabilities to tie or win. Weaker teams, over time, have adopted strategies to cope with the widening team qualities and whatever these strategies are, they are characterized by a lower scoring context. Fernández-Cantelli and Meeden (2003: 4) have used this same property to explain why weaker teams tend to play conservatively as long as the contest is in a tie position:

By playing very defensively the weaker team is decreasing the scoring rates for both teams to values closer to zero. When both of the Poisson mean parameters are quite small both teams have expected winnings close to one [league point]. This is better for the weaker team than playing normally. Hence playing defensively or conservatively is in effect shortening the game. This makes sense intuitively since the shorter the game the less chance the better team has to demonstrate its superiority.
A paradigmatic example is the strategy adopted by Portugal against The Netherlands at the quarter-finals of the World Championship football in Germany, 2006. By all means the Portuguese were minimizing the effective playing time. In fact, what they revealed was that they were the weaker team, and by resorting to that strategy their chance of surviving this knock-out match increases.

Second, inclusion of the scoring context in the analysis also tells us that any measure to increase the number of goals per match can be expected to lead to a lower CB. Included here are the various proposals to enlarge the goals; to handicap the goalkeepers by disallowing catching; and/or the abolition of sliding. The higher the average number of goals per match, the higher the scoring context, the higher the winning resolution and the lower the level of CB at a given distribution of team qualities. So, an increase in goals per match is inevitably bought against a less exciting competition. Obviously, there is a policy dilemma here: measures to make the game more entertaining (i.e. more goals) will lead to a lower average degree of ‘suspense’ (i.e. a lower level of CB, so lower match uncertainty, seasonal uncertainty and championship uncertainty). In a nutshell, measures that increase short-term excitement are therefore seen to erode a healthy CB and reduce long-term enjoyment.

**Conclusion**

European football has characteristics that Americans mostly dislike, such as the low number of goals per match, the frequent occurrence of ties and that games are decided by erratic referees, but these same characteristics do a great service to European football, namely they keep the natural level of CB high. If Europeans would go for the American way of team sports, with many goals, more intense refereeing and overtime, the flip side would be that highly artificial measures are necessary, as in American team sports, to maintain CB.

Despite the gradual decline in the scoring context (i.e. the average number of goals per match) over the last century – which by itself was seen to exert an upward pressure on CB – CB has decreased. Both developments are regrettable and linked to each other. My conjecture is that because team qualities have widened, as manifested in a decline of CB, weaker teams tend to adopt (mainly defensive and time wasting) strategies in order to reduce the average number of goals per match and raise the chance of drawing or winning against better teams. Both developments are unfortunate because the decline in CB compromises the level of suspense while a lower average number of goals per match reduces the entertainment value. Football associations, both at the national and the UEFA levels, would therefore be well-advised to raise the level of CB in domestic leagues and the European cup competitions. Doing so would make European football more exciting as well as more entertaining in the future. In addition, I have illustrated that the notoriously imperfect referee in European football must be maintained – instead of introducing a TV monitoring fifth official assisting the referee – as long as wrong decisions are made impartially and randomly. The idiosyncrasy of referees’ aberrations, I have shown, is conducive to maintaining CB.

**Appendix A: Competitive Balance and the Role of a Fallible Impartial Referees**

Whilst the roles of the referee and his assistants remain the same, the fourth official should be in charge of keeping control of events on the sidelines and a fifth official should be introduced, who spends the game
watching a TV monitor. This official will have an important role, as he will contact and advise the referee via the headsets that have been seen in use by officials during the World Cup. (www.petitiononline.com/FIFAFIX/petition.html)

In the Donald Duck paperback *Football Fever*, Gyro Gearlose invents an infallible referee. This robot-referee, with caterpillar tracks, can decide meticulously whether a ball has passed the line or not, whether it was offside or not, and so on. It can even see what is going on behind its back, thanks to a camera in a hidden place on its body. When players or coaches disagree, the robot-referee sends the images to a giant screen, so that everyone can see that it was right, as always. Uncle Scrooge McDuck sells the robot for big money to the football association and Donald is rewarded with a season ticket; after all, it was his idea and he did teach the robot all the rules! However, after some weeks, fan attendance drops, a commentator is fired and even Donald prefers to stay at home instead of going to the Sunday afternoon match. Pressure mounts and so, before the season comes to an end, the robot-referee is abolished and everything returns to normal; that is, the fans, players, commentators and coaches return to their quarrelling over the referee’s controversial decisions. The grain of truth in the story is that a perfect, infallible referee is no improvement for soccer.

My claim is that due to the notoriously erratic performance of referees in soccer, CB is higher than it otherwise would be, provided errors are made in an impartial way. This can again be nicely illustrated by means of a Poisson process of scoring goals. For simplicity it is assumed that the referee takes a discretionary decision to grant at random one of the teams an extra irregular goal, e.g. by allowing a goal that should have been disallowed. Consider then a league of two teams, where team B is the superior team, characterized by the Poisson parameters $\mu = gf > \nu = ga = 1$. Table A.1 gives the outcome probabilities for $\mu = 2$, $\nu = 1$ for up to five goals for or against (in theory, the score is infinite, but the probabilities of scoring more than five goals become extremely small and so these are excluded). To get the winning percentage equivalent for the weaker team A, one must simply sum the $P(\text{win})$ plus half the sum of $P(\text{tie})$. Note that these are the probabilities that result under the ideal of a perfect referee. This gives a winning percentage for team A of 28.9 per cent (see the last row of Table A.1 on the right).

<table>
<thead>
<tr>
<th>$GA \downarrow GF \rightarrow$</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>$Pr$</th>
<th>$P(\text{win})$</th>
<th>$P(\text{tie})$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.05</td>
<td>0.1</td>
<td>0.1</td>
<td>0.066</td>
<td>0.033</td>
<td>0.013</td>
<td>0.368</td>
<td>0.00</td>
<td>0.05</td>
</tr>
<tr>
<td>1</td>
<td>0.05</td>
<td>0.1</td>
<td>0.1</td>
<td>0.066</td>
<td>0.033</td>
<td>0.013</td>
<td>0.368</td>
<td>0.05</td>
<td>0.1</td>
</tr>
<tr>
<td>2</td>
<td>0.025</td>
<td>0.05</td>
<td>0.05</td>
<td>0.033</td>
<td>0.017</td>
<td>0.007</td>
<td>0.184</td>
<td>0.08</td>
<td>0.05</td>
</tr>
<tr>
<td>3</td>
<td>0.008</td>
<td>0.017</td>
<td>0.017</td>
<td>0.011</td>
<td>0.006</td>
<td>0.002</td>
<td>0.061</td>
<td>0.04</td>
<td>0.011</td>
</tr>
<tr>
<td>4</td>
<td>0.002</td>
<td>0.004</td>
<td>0.004</td>
<td>0.003</td>
<td>0.001</td>
<td>0.001</td>
<td>0.015</td>
<td>0.01</td>
<td>0.001</td>
</tr>
<tr>
<td>5</td>
<td>0.001</td>
<td>0.001</td>
<td>0.001</td>
<td>0.001</td>
<td>0.001</td>
<td>0.001</td>
<td>0.001</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>$Pr$</td>
<td>0.135</td>
<td>0.271</td>
<td>0.271</td>
<td>0.180</td>
<td>0.090</td>
<td>0.036</td>
<td>1</td>
<td>$w = 0.2890$</td>
<td></td>
</tr>
</tbody>
</table>

Now suppose the referee grants at random an extra goal to one of the teams. In half of the cases the goal is granted to B’s opponent A and thus $GA$ increases by one. In the other half, $GF$ increases by one. Of course, the scoring probabilities ($\mu$ and $\nu$) of regular goals remain unchanged. The situation where A is granted one goal can be

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5 Of course, if the wrong decisions of the referee are biased in favour of better teams, then more perfect refereeing will also raise the CB.
represented by increasing $GA$ of Table A.1 by one, thus the row headings of $GA$ change from \{0,1,2,...\} to \{1,2,...\}. Naturally, new values for $P(\text{win})$ and $P(\text{tie})$ are obtained for each possible outcome, as illustrated in Table A.2. The win percentage of team A rises to 51.5 per cent.

**Table A.2** Outcome probabilities under a referee granting the away team one goal ($GA$ increased by one)

<table>
<thead>
<tr>
<th>$GA \downarrow GF \rightarrow$</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>$Pr$</th>
<th>$P(\text{win})$</th>
<th>$P(\text{tie})$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.05</td>
<td>0.1</td>
<td>0.1</td>
<td>0.066</td>
<td>0.033</td>
<td>0.013</td>
<td>0.368</td>
<td>0.05</td>
<td>0.1</td>
</tr>
<tr>
<td>2</td>
<td>0.05</td>
<td>0.1</td>
<td>0.1</td>
<td>0.066</td>
<td>0.033</td>
<td>0.013</td>
<td>0.368</td>
<td>0.15</td>
<td>0.1</td>
</tr>
<tr>
<td>3</td>
<td>0.025</td>
<td>0.05</td>
<td>0.05</td>
<td>0.033</td>
<td>0.017</td>
<td>0.007</td>
<td>0.184</td>
<td>0.125</td>
<td>0.033</td>
</tr>
<tr>
<td>4</td>
<td>0.008</td>
<td>0.017</td>
<td>0.017</td>
<td>0.011</td>
<td>0.006</td>
<td>0.002</td>
<td>0.061</td>
<td>0.053</td>
<td>0.006</td>
</tr>
<tr>
<td>5</td>
<td>0.002</td>
<td>0.004</td>
<td>0.004</td>
<td>0.003</td>
<td>0.001</td>
<td>0.001</td>
<td>0.015</td>
<td>0.014</td>
<td>0.001</td>
</tr>
<tr>
<td>6</td>
<td>0</td>
<td>0</td>
<td>0.001</td>
<td>0.001</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.003</td>
<td>0</td>
</tr>
<tr>
<td>$Pr$</td>
<td>0.135</td>
<td>0.271</td>
<td>0.271</td>
<td>0.18</td>
<td>0.09</td>
<td>0.036</td>
<td>1</td>
<td>$w = 0.5150$</td>
<td></td>
</tr>
</tbody>
</table>

The other situation, where B is granted an extra goal, is depicted in Table A.3 (here, Table A.1 is reproduced by increasing all column headings by one goal). The win percentage for A decreases to 12.30 per cent. Because we have assumed that both cases are equally likely, the average win percentage with the randomizing referee is $(51.5+12.3)/2 = 31.9$ per cent, which is 3-percentage points more than the original 28.9 per cent in a world of perfect refereeing. As a result, an impartial but erratic referee is seen to be to the advantage of the weaker team and thus increases the CB. Intuitively, the impact of one faulty decision by the referee is larger, the lower the scoring context. Given a declining scoring context, this can be seen as a conducive second order effect on the degree of CB.

This leads us to the following conclusions. First, the adoption of TV monitoring and other features to help the referee and linesmen means that the right decisions will be bought at the price of a lower CB. Second, in the previous section we saw that the average number of goals per match declines. The higher the average number of goals per match, the smaller the role of the referee, since the chance that one or a few faulty decisions will change the outcome is smaller. However, if the average number of goals per match is very low, a single idiosyncratic decision may determine the outcome. So, we may say that along with the decline in scoring context in the last century, the importance of the role of the referee has increased.

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*In the next section, it will be shown that home advantage and away disadvantage leads to a slightly higher level of CB. If the hypothesis is true that home advantage and away disadvantage is caused by the referee (see e.g. Nevill et al. 2005), that is, the referee is ‘a homer’ in taking marginal decisions, then TV monitoring might eliminate it, which will also lead to less CB. This is because in the extreme case where the referee is a perfect homer and always directs the game to a win for the home team, the CB is at its maximum.*
According to the first conclusion – that is, TV monitoring reduces CB – TV monitoring is not a good idea when seen from the perspective of maintaining a high level of CB. There are other considerations, however, that make the device unattractive. On the website Ask the Referee, referee Chuck Fleischer says that ‘Sometimes we miss something important BUT it is far better to have it that way than stop play and crowd around a television monitor to dissect what did or did not happen’. Note that if one wants to further commercialize football by inserting commercial breaks during the live broadcast of a match, then the interruptions to allow the fifth official to do his work is an exquisite opportunity. According to Sandy, Sloane and Rosentraub (2004) it is very likely that Europe will follow the US practice of commercial breaks during the match: ‘The implication for sports broadcasting in Europe… is that there may soon be commercial breaks in soccer. Soccer has natural breaks after goals or injuries so the technical adjustments would be minor. As the fraction of viewers who are watching broadcasts compared to watching live increases in Europe the financial pressure to have commercial breaks will be inexorable.’ Another disadvantage of TV monitoring is that it would quickly evolve to the situation that on all levels, ranging from pupils to veterans, television or video monitoring is required to complete a match adequately. The attractiveness of the present, primitive, way, with all its shortcomings, is that football is played everywhere, ranging from Wembley to the squares of the cities and villages of Ghana, with the same means – a football, a field, some lines and a referee supported by two linesmen (as the fourth official has not yet entered the stage below the highest levels).

Appendix B: Competitive Balance and Home and Away (dis)advantage

In this appendix it is shown that the same method can be used to simulate the impact of home and away (dis)advantage versus playing on neutral ground on CB. At face value, home advantage (and away disadvantage) is considerable. For England 1888-2006, the winning equivalent of the home team is on average about twice that of the away team (0.67 versus 0.32). At the extreme, if the home team always win, the CB is perfect. However, despite the clear home advantage in European football, its effect on the level of CB is very modest.

The situation where two teams A and B play at home and away against each other can schematically be put as follows:
A’s scoring propensity is composed of two elements, its propensity to score goals when playing at home, denoted by $\mu_A$, and its propensity to score goals when playing away, denoted by $\nu_B$. We use $\nu_B$ for the latter because A’s propensity to score goals away is in fact the parameter covering the expected number of goals against for team B playing at home. Analogously, B’s propensity to score goals at home is $\mu_B$ and to score away is $\nu_A$. In the equations above, there are three exogenous parameters. The parameter $r$ denotes the propensity to score goals at home and away of team A relative to team B. A is the weaker team, so $r < 1$. The home advantage is expressed by the parameter $h$ and reflects the ratio of the average number of goals scored at home and the average number of goals scored away. In the period 1888–2006 in England’s highest level competition, the average number of goals scored by the home team is 1.87, the average number of goals scored by the away team is 1.18, which gives a ratio of 1.59. Finally, $s$ denotes the scoring context or the average total number of goals per match, which is on average 3.05 over the entire period 1888-2006.

Solving Eqs. (6.1)-(6.4) gives the following expression for the scoring propensities of A and B:

\begin{align*}
(6.1) \quad (\mu_A + \nu_B) &= r(\mu_B + \nu_A) \\
(6.2) \quad \mu_A &= h\nu_B \\
(6.3) \quad \mu_B &= h\nu_A \\
(6.4) \quad \mu_A + \mu_B + \nu_A + \nu_B &= 2s
\end{align*}

with

$r =$ propensity to score goals at home and away of team A relative to team B; \\
$h =$ home advantage parameter; \\
$s =$ scoring context.

Now we turn to the situation that the match between A and B is played on neutral ground. This situation can be simulated by assuming that the total goals scored per team is evenly divided between playing at home and away. With home advantage team A scores $\mu_A$ goals for and because of the away disadvantage the goals scored away for team A is only $\nu_B < \mu_A$. For team A’s hypothetical scoring propensity on neutral ground, we take the average of its propensity to score goals at home and away, so $(\mu_A + \nu_B)/2$. In fact, what we do is replace Eqs. (6.2)-(6.3) by:

\begin{align*}
(7.1) \quad \mu_A &= \frac{2hrs}{(1 + h)(1 + r)} \\
(7.2) \quad \mu_B &= \frac{2hs}{(1 + h)(1 + r)} \\
(7.3) \quad \nu_A &= \frac{2s}{(1 + h)(1 + r)} \\
(7.4) \quad \nu_B &= \frac{2rs}{(1 + h)(1 + r)}
\end{align*}

Now we turn to the situation that the match between A and B is played on neutral ground. This situation can be simulated by assuming that the total goals scored per team is evenly divided between playing at home and away. With home advantage team A scores $\mu_A$ goals for and because of the away disadvantage the goals scored away for team A is only $\nu_B < \mu_A$. For team A’s hypothetical scoring propensity on neutral ground, we take the average of its propensity to score goals at home and away, so $(\mu_A + \nu_B)/2$. In fact, what we do is replace Eqs. (6.2)-(6.3) by:

$$\mu^*_A = (\mu_A + \nu_B) / 2 = \nu^*_B$$  \hspace{1cm} (8.1)
\[ \mu^n_B = (\mu_B + \nu_A) / 2 = \nu^n_A \]  \hspace{1cm} (8.2)

where the superscript \( n \) denotes neutral ground. Alternatively, Eqs. (8.1)-(8.2) can be interpreted as equal scoring propensities at home and away. To isolate the home and away (dis)advantage effect, we maintain Eqs. (6.1) and (6.4), that is, the ratio of team A’s scoring propensity relative to B is kept constant as well as the scoring context:

\[ \mu^n_A + \nu^n_B = r(\mu^n_B + \nu^n_A) \]  \hspace{1cm} (8.3)

\[ \mu^n_A + \nu^n_B + \mu^n_B + \nu^n_A = 2s \]  \hspace{1cm} (8.4)

Solving Eqs. (8.1)-(8.4) gives:

\[ \mu^n_A = \nu^n_B = \frac{rs}{1+r} \]  \hspace{1cm} (9.1)

\[ \mu^n_B = \nu^n_A = \frac{s}{1+r} \]  \hspace{1cm} (9.2)

With A being the weaker team \((r < 1)\), playing with home and away (dis)advantage compared to playing only on neutral ground is to the advantage of A if and only if:

\[ \Delta^{HA} = \frac{1}{2}WE^A_h + \frac{1}{2}WE^A_a - WE^A_n > 0 \]  \hspace{1cm} (10)

Table 3 provides the simulation results for different values of \( r \), where the parameters \( h \) and \( s \) are set equal to 1.59 and 3.05 respectively, corresponding to the average ratio of goals scored home and away and the average number of total goals per match during the period 1888-2006. It shows that the home and away (dis)advantage has a beneficial, but small, effect on CB, that is, it raises the winning equivalent of the weaker team compared to playing on neutral ground.

Table 3. The winning equivalents of playing at home and away versus playing on neutral ground for the weaker team.

<table>
<thead>
<tr>
<th>( r )</th>
<th>( WE^h )</th>
<th>( WE^a )</th>
<th>( WE^n )</th>
<th>( \Delta^{HA} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.05</td>
<td>0.085</td>
<td>0.032</td>
<td>0.044</td>
<td>0.015</td>
</tr>
<tr>
<td>0.1</td>
<td>0.125</td>
<td>0.041</td>
<td>0.067</td>
<td>0.016</td>
</tr>
<tr>
<td>0.2</td>
<td>0.209</td>
<td>0.068</td>
<td>0.120</td>
<td>0.018</td>
</tr>
<tr>
<td>0.3</td>
<td>0.289</td>
<td>0.101</td>
<td>0.176</td>
<td>0.018</td>
</tr>
<tr>
<td>0.4</td>
<td>0.362</td>
<td>0.137</td>
<td>0.233</td>
<td>0.017</td>
</tr>
<tr>
<td>0.5</td>
<td>0.428</td>
<td>0.175</td>
<td>0.287</td>
<td>0.015</td>
</tr>
<tr>
<td>0.6</td>
<td>0.485</td>
<td>0.213</td>
<td>0.337</td>
<td>0.012</td>
</tr>
<tr>
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<td>0.250</td>
<td>0.384</td>
<td>0.009</td>
</tr>
<tr>
<td>0.8</td>
<td>0.578</td>
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<td>0.426</td>
<td>0.006</td>
</tr>
<tr>
<td>0.9</td>
<td>0.616</td>
<td>0.319</td>
<td>0.465</td>
<td>0.003</td>
</tr>
<tr>
<td>1.0</td>
<td>0.649</td>
<td>0.351</td>
<td>0.500</td>
<td>0.000</td>
</tr>
</tbody>
</table>
Figure 6. Winning equivalents under home and away (dis)advantage versus on neutral ground.

Figure 6. Difference in winning equivalents under home and away (dis)advantage versus on neutral ground for the weaker team.

References