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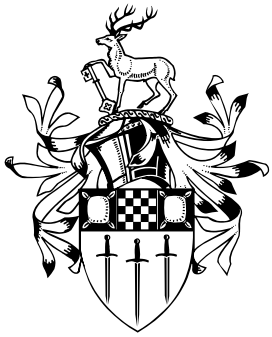

**Discussion Papers in Economics**

# FAVOURITISM AND FINANCIAL INCENTIVES: A NATURAL EXPERIMENT


Neil Rickman
(University of Surrey & CEPR)

&

Robert Witt
(University of Surrey)



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Department of Economics
University of Surrey
Guildford
Surrey GU2 7XH, UK
Telephone +44 (0)1483 689380
Facsimile +44 (0)1483 689548
Web www.econ.surrey.ac.uk

# Favouritism and financial incentives: A natural experiment*

Neil Rickman
University of Surrey
and CEPR

Robert Witt
University of Surrey

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**Abstract**

Principals who exercise favouritism towards certain agents may harm those who are not so favoured. Other papers have produced evidence consistent with the presence of such favouritism but have been unable to consider methods for controlling it. We address this issue in the context of a natural experiment from English soccer, where one particular league introduced professional referees in 2001-02, thereby changing the financial incentives and monitoring regime faced by these referees. Because the change was not effected in all leagues, the 'experiment' has both cross-sectional and intertemporal dimensions. We study the effects of professional referees on an established measure of referee bias: length of injury time in close matches. We find that referees exercised favouritism prior to professionalism but not afterwards, having controlled for selection and soccer-wide effects. The results are consistent with a financial incentive effect as a result of professional referees and indicate that subtle aspects of principal-agent relationships (such as favouritism) are amenable to contractual influence.
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**Keywords:** Favouritism, financial incentives, soccer, referee.

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# 1 Introduction

A central tenet of principal-agent theory is that a combination of financial rewards and (imperfect) monitoring can be used by principals to incentivise their agents. In particular, the purpose of such instruments is to have the agent (at the expense of some information rent) internalise the principal's preferences when performing his/her tasks. A literature, has developed to test the extent to which such incentive contracts perform the roles they are designed for. The papers here are well summarised in Prendergast (1999) and cover settings as diverse as executive compensation schemes and the cost of legal aid in England and Wales (Gray *et al.* (1999)).

Recent work has highlighted an additional source of inefficiency in principal-agent relationships: the favouritism that principals can show towards chosen agents. In theory, this can influence numerous economic settings. Thus, Prendergast and Topel (1996) show how favouritism can bias the evaluation of agents' performance in organisations and, in turn, their behaviour. Similarly, large-scale public expenditure decisions can be afflicted by such behaviour: for example, the choice of procurement partner by government departments (Naegelen and Mougeot (1998)) and the regional allocation of public goods in the presence of political bias (Zantman (2002)). In fact, it seems likely that most people will recognise circumstances where favouritism has (or could have) been exercised by principals and this raises the important question of how such behaviour may be controlled.[1]

A potential answer to this question may be to use financial incentives. Such a possibility arises when (as is often the case) the principals favour-

[1] "Control" of favouritism is a more appropriate objective than its eradication: as Prendergast and Topel (1996) show, to the extent that parties enjoy exercising favouritism, its eradication removes a source of welfare.

ing particular agents are, themselves, agents to a higher principal who may wish to control such behaviour. For example, Prendergast and Topel (1996) model the favouritism exercised by "supervisors" towards "workers" in a manager-supervisor-worker hierarchy. They show that the "managers" can use financial incentives to control supervisors' favouritism. Inspired by this insight, the current paper provides the first test (to our knowledge) of the extent to which financial incentives can help control favouritism in such hierarchical principal-agent settings. In particular, we ask whether a governing body in soccer can influence the favouritism displayed by referees towards players/teams.

Empirical studies of favouritism in general are limited by the difficult task of its identification but soccer has recently proved a fruitful setting for such analysis.[2] Garicano *et al.* (2004) find evidence that soccer referees favour home teams when adjudicating matches. Using data from Spanish soccer, the authors find that referees add more injury time when the home team is behind in a close game than when it is ahead in a close game (as opposed to those where the scores are too far apart for additional injury time to make a difference). They attribute this "favouritism" to the social pressure applied by home team supporters. The evident measurability of this favouritism has encouraged several similar studies based on other soccer leagues. Using additional control variables, Dohmen (2003), Sutter and Kocher (2004) and Lucey and Power (2004) all produce a qualitatively similar finding on injury time to Garicano *et al.* (2004)'s in German, Italian and US soccer leagues respectively. In addition, Dohmen (2003) and Sutter and Kocher (2004) also discover that referees are more inclined to award penalty kicks for the home

[2]Favouritism has also received empirical examination in used car markets (Knowles *et al.* (2001): racial bias) and, indeed, in academic publishing (Medoff (2003): editorial bias).

team as opposed to the away team (see also Nevill *et al.* (1996)). Finally, Nevill *et al.* (2002) use a series of controlled experiments with video-taped matches and actual referees to show that crowd noise can influence refereeing decisions.[3]

To perform our analysis, we make use of a natural experiment that took place in English soccer in 2001-02. This season saw the introduction of professional referees to the English Premier League.[4] For the first time, a group of referees were retained for the whole soccer season on a full salary (plus match fees) and, in addition, were subjected to a new regime of monitoring and performance appraisal. Along with the intertemporal comparison in performance that this provides, the fact that only the Premier League (in contrast to the leagues below it) introduced this change means that the natural experiment also contains a cross-sectional dimension.

Like the papers cited above, we first establish the presence of favouritism in our data using Garicano *et al.* (2004)'s approach: looking for the first time at the relationship between injury time and home team match position in close games for English soccer. We discover favouritism similar to (though smaller than) Garicano *et al.* (2004)'s in the pre-professional English Premier League. Interestingly, although other authors have interpreted the degree of favouritism as representing the extent of social pressure exerted by home team fans, our result need not in fact imply a lack of such pressure. With average distances between grounds smaller in England than Spain and the

[3]The presence of home bias amongst sports referees has received attention from a variety of disciplines (see the surveys in Courneya and Carron (1992) and Nevill and Holder (1999)); while psychologists and health scientists have uncovered a number of potential causes of such behaviour (e.g. Tversky and Kahneman (1974), Wickens and Hollands (2000) and Neave and Wolfson (2003)). More generally, economists have also discussed the interaction between 'social' factors and market outcomes (e.g. Becker and Murphy (2000)).

[4]See NCCFR (2002) for the reasons behind this change.

US (where larger biases have been found), most matches contain a larger proportion of away team supporters who might, themselves, apply a measure of countervailing social pressure.[5] However, we find that favouritism disappears in our post-professional Premier League data: this suggests a clear response to the incentives introduced by the policy.[6]

We address two possible arguments that could contradict this conclusion. First, it could be argued that we are picking up a 'quality' effect in the sense that the best referees are used in the Premier League and, as such, they are best able to ignore tendencies towards favouritism. Our use of fixed effects controls for this selection bias but does not remove the effect we find from professionalism. Second, it may be that (for whatever reason) the reductions in score-dependent injury time that we find could have happened across English professional soccer in general; again, this would limit the extent to which financial incentives were controlling favouritism. As noted above, we are able to use contemporaneous data from the English First Division (as it was called during our data period) and this allows us to control for such a soccer-wide effect. Again, our conclusion still holds.

The paper is structured as follows. The following section provides more detail on the switch to professional referees that underlies our natural experiment. Section 3 then presents our data and descriptive statistics before

[5]The lower levels of favouritism in Italy (Lucey and Power (2004)) could also be explained in a similar way.

[6]Of the papers cited earlier, Garicano *et al.* (2004) are clear that their paper examines only "non-monetary incentives" (p. 11) and this is also true in Sutter and Kocher (2004). Dohmen (2003) uses German data over nine seasons in which he reports increases in the fees paid to referees but he does not seek to identify any relationship between fee rises and levels of bias. In fact, the changes in bias that he does observe are not systematic). Lucey and Power (2004) note smaller levels of bias in Italy than the US and imply that this may be related to the higher financial rewards for referees in the former. Neither of these papers provides a satisfactory basis for examining the role of financial incentives in controlling favouritism: what is needed is an explicit exogenous change in the financial incentives faced by referees such as the one we examine.

Section 4 sets out our results. The concluding section discusses our results and suggests extensions to our work.

# 2 Professional soccer referees

Referees (along with two assistants) officiate at all soccer games. Their task is to adjudicate incidents according to rules laid down by the Federation of International Football Associations (FIFA), to apply appropriate sanctions when they deem these rules have been broken, and to time proceedings so that 90 minutes of play (in two halves of 45 minutes) take place—this will typically require additional time to compensate for stoppages resulting from, say, player injuries, player substitutions and time wasting by the players. During the game, the referee is the sole adjudicator of infringements and exercises considerable discretion when interpreting players' actions and deciding appropriate responses.

When referees turned professional in 2001, the Professional Game Match Officials Board (PGMOB) replaced the National Review Board. Its task was to provide match officials for all professional games played in England and to assess their performance throughout the season. Officials were divided into two broad groups. First, the Select Group, currently comprising 19 referees and 38 assistant referees, officiate at the top games including all those in the English Premier League.[7] Second, the National List of officials includes over two hundred individuals as referees and assistant referees who officiate in the remaining professional game fixtures.

Perhaps the most significant change introduced by professional referees

[7]These referees also officiate at some Football League games and certain FA Cup and League Cup games.

related to their remuneration. Prior to the 2001-02 season, referees were employed as amateurs and earned as little as a few hundred pounds per game (plus expenses)—see NCCFR (2002). They also received little training. In contrast, professional referees received an annual retainer fee of £33,000 plus £900 per game and were obliged to attend a number of training sessions organised by the PGMOB. Most referees also work in other professions during the week.

The new professional status of referees was inevitably combined with increased scrutiny of their performances. Measures to introduce greater accountability included (i) fortnightly meetings to discuss examples of good and bad refereeing practice, (ii) monitoring from the stands and reports from managers and Professional Footballers Association representatives, and (iii) intensive training and stringent fitness tests designed to ensure that referees could perform to the best of their ability. Referees deemed to have performed poorly face a number of sanctions, the ultimate one being either temporary or permanent removal from the professional list, with associated implications for income and status.[8]

To summarise, soccer referees exercise considerable discretion when officiating games and this may encourage favouritism in their decision making. Top-level referees in England and Wales have recently received a significant increase in the remuneration they receive, coupled with improved monitoring of their performances. To the extent that this policy implies a credible, and high, opportunity cost to making poor decisions, it might be expected to have reduced scope for favouritism amongst top referees. The remainder of the paper seeks to test this conjecture. We begin by presenting our data.

[8]For instance, referee Andy D'Urso received a 28-day ban in September 2004 for incorrectly sanctioning a player.

# 3 Data

At the level of professional soccer *players* (as opposed to *referees*), English soccer is divided into four national leagues. We have data from the top two of these: the Premier League (whose referees became professional in 2001-02) and, below this, the First Division (whose referees remained 'amateur').[9] The former consists of twenty teams who play each other home and away during a season (yielding a total of 38 matches per team); the latter consists of twenty-four teams, again playing each other home and away (meaning 46 matches per team in a season). Each season, three teams are relegated from the Premier League to the First Division, with three teams being promoted in the opposite direction and three teams also being relegated from the First Division. Thus, as the season progresses, matches develop added significance.

For every match in these two leagues (for the seasons 1999-00 and 2002-03), we have data on the goals scored by home and visiting teams, the injury time added by the referee at the end of the first and second halves of play, sanctions handed out by referees to players for infringements of the rules ('yellow cards' for moderate infringements and 'red cards' for significant infringements[10]), crowd attendance figures and the names of referees who were in charge of each game. These data come from the Press Association. In addition, we also have information on the timing of goals scored in injury time in the Premier League (from Opta Index). Equivalent data are not available for the First Division; instead, goals occurring in or after the final minute of each half are timed at either 45 or 90 minutes. We assume that goals recorded

[9]Since August 2004, the First Division has been called the Championship but, as our data pre-date this change of name, we refer to it throughout by its previous name.

[10]Two yellow cards constitute a red card which, in turn, means a player's ejection from the game and his side's numbers being reduced accordingly for the remainder of the game.

in this way in the First Division are injury time goals.[11] The data on the remaining variables come from several sources. Player substitutions during each game come from the `www.soccerbase.com` website. Annual turnover measures for Premier League clubs were gathered from annual balance sheets and profit and loss accounts lodged with Companies House. Table rankings of home teams at the end of the season and ground capacity were collected from relevant Rothman's Football Yearbooks.

Before proceeding to discuss our results, it is useful to consider our choice of seasons for analysis (1999-00 and 2002-03). Clearly, it is important for us that these seasons span the onset of professional Premier League referees (in 2001-02). By not using the seasons immediately before and after the new professional referee era, we aim to avoid potential anticipation effects (in 2000-01) and disequilibrium responses (in 2001-02). Accordingly, we believe our data are suitable for distinguishing the 'steady-state' effects of professional referees.

Tables 1A and 1B provide summary statistics for the variables used in this analysis over the seasons 1999-00 and 2002-03 and in the Premiership and First Division, respectively. The data cover 760 Premier League matches (i.e. 20 teams playing 19 home games in each of two seasons) and 1,104 First Division games (i.e. $24 \times 23 \times 2$). Both tables display similar patterns, with a little quantitative difference. Thus, in both leagues, home teams won on average (by nearly half a goal in the Premier League, and just over a third of a goal in the First Division). In both cases, home teams scored roughly

[11] Our Opta Index data show that ninety per cent of goals timed at either 45 or 90 minutes in the Premier League in the 1999-00 season were scored during injury time. This compares with 70 per cent in the 2002-03 season. Thus, our assumption for the First Division is likely to be reasonable. It is certainly implausible that most goals timed at 45 or 90 minutes were scored at precisely that time, with only a small number being scored in injury time.

1.5. goals per game, with visitors netting a little over one. Second-half injury time produced more goals for home and away teams in both leagues. In part, this reflected the longer duration of second-half injury time. First Division injury time was longer than in the Premier League, reflecting in part the slightly higher number of player substitutions in that league. Furthermore, home teams scored more goals in both first- and second-half injury time, in both leagues. As might be expected for the higher profile league with larger clubs, Premier League attendances averaged more than twice those in First Division, with grounds almost 90% full; First Division grounds were roughly two-thirds full.

# 4 Results

The exogenous change of rewards to referees in the Premier League in the 2001-02 season, presents a unique opportunity of testing whether referees respond to financial incentives. In Table 2 we test for this using specifications very similar to those used in Garicano *et al.* (2004). The dependent variable is second half injury time in games where the goal difference is one; i.e. games that are 'close' in the sense that their outcome could be altered by a few more seconds of play. As in Garicano *et al.* (2004), favouritism is captured by the coefficient on the SCORE DIFFERENCE dummy which is equal to one if the home team is ahead by one goal and zero if the home team is behind by one goal. The estimated coefficient on this dummy reported in column (i) is negative, small in magnitude but strongly significant (i.e. at 1%). On average, injury time is shorter by 18 seconds, substantially lower than the estimate of 1.88 minutes in Garicano *et al.* (2004). However, as columns (ii)–(iv) in Table 2 indicate, the presence of additional regressors increases

our measured favouritism to roughly 30 seconds, in each case with strong statistical significance.[12]

In columns (ii)–(iv) in Table 2 we test for the change in financial rewards of referees by including interaction terms between the YEAR of observation and the SCORE DIFFERENCE dummy. The interaction term SCORE DIFFERENCE × YEAR is positive and significant. The estimated coefficients roughly offset those on SCORE DIFFERENCE, suggesting that the favouritism of roughly 30 seconds is more-or-less removed after the introduction of professional referees. This is consistent with the introduction of professional referees generating strong enough financial incentives to influence referees' behaviour.[13]

There are two important concerns with the results discussed above. First, perhaps the highest quality referees are offered professional contracts, in which case, we might simply be picking up a selection bias as opposed to the effects of financial incentives *per se*. We address this issue by employing referee fixed effects in column (iv) of Table 2. Thus, the results reported above ultimately control for potential quality effects.

[12]It should be noted from Tables 1A and 1B that measured injury time itself is also lower in our data than in Garicano *et al.* (2004)'s. This partially explains the lower amount of favouritism that we find. As mentioned in the Introduction, is it also likely that the greater preponderance of away team supporters at English games (as a result of shorter travel distances) exert a social pressure to counter that postulated by Garicano *et al.* (2004).

[13]We have also looked at whether the 'closeness' of a game matters. For example, we find that the SCORE DIFFERENCE dummy is small and statistically insignificant when there is a two-goal difference in the score at the end of the second half. This finding is consistent with the evidence in Garicano *et al.* (2004) and contributes to the view that the differences in injury time are related to the prospects that they can alter match outcomes. To investigate further the issue of favouritism, we have also tested whether referees end the game quicker after a home goal is scored in injury time than an away goal. In the Premier league during the 1999-00 and 2002-03 seasons, there were 77 games in which either the home team or the away team scored one goal in second half injury time. We found no evidence to suggest that the amount of injury time depended on who scored. This is in contrast to the findings in Garicano *et al.* (2004).

The second important concern relates to the fact that the professional referee group does not cover other leagues, so that the reduction in favouritism we have found may simply reflect a trend across all of English football. A particular strength of our data is that we are able to use First Division matches as a control group (given that referees here remained amateur) in order to control for such a 'soccer-wide' effect.

Table 3 presents basic statistics on average injury time in games which ended with a one goal difference before and after the introduction of professional referees, across the two football leagues. The top two rows in Table 3 show the effect of professional referees on first half injury time in the Premier League, in which the employment of professional referees was an innovation relative to the pre-2001-02 season, and the control group (First Division), in which they were not. Average first half injury time with the treatment group (Premier League) decreased by a statistically significant 0.205 minutes (from 1.926 to 1.721). However, for the control group (First Division) there was an increase of 0.206 minutes. Our first estimate of the injury time response then is -0.411, with a standard error of 0.163. Looking still further down Table 3 to the comparison of second half injury time in the Premier League and the First Division, a similar pattern emerges. Injury time before 2001 was 2.874 minutes in Premier League games, compared with 3.083 minutes for the First Division. After 2001 there was an increase in injury time of 0.41 minutes (2.874 to 3.284) for the Premier League. There was a 0.724 increase in minutes for the control group. Taken together, these figures suggest a response of -0.314 minutes. On balance, then, the unconditional difference-in-difference estimates in Table 3 point to a fall in injury time added by referees when professional in the Premier League compared to the control group of the First Division.

Table 4 moves to a regression framework, employing the straightforward differences-in-differences-in-differences specification. The dependent variable is the length of injury time in games that ended with a one goal difference. The PREMIER LEAGUE dummy variable is equal to 1 for games in the Premiership and 0 for games in the First Division. Favouritism is again captured by the SCORE DIFFERENCE dummy variable, which equals 1 if the home team is ahead by one goal and 0 if the home team is behind by one goal. YEAR denotes a dummy variable equal to 1 in the post-professional referee period (2002-03 season) and 0 for games in the pre-professional period (1999-00 season). The coefficients of central interest in Table 4 are those on the triple interaction term, PREMIER LEAGUE $\times$ SCORE DIFFERENCE $\times$ YEAR. The coefficient measures the change between the pre- and post-professional referee periods in Premier League compared to First Division second half injury time in games when the home team is leading by one goal.

The results in Table 4 are consistent with the preliminary findings in Table 2. As the coefficients on PREMIER LEAGUE $\times$ SCORE DIFFERENCE show, on average injury time is shorter in the Premiership by roughly 25 seconds when the home team is ahead by one goal. However, the introduction of professional referees had a significant positive effect on second half injury time in the Premier League compared to the First Division. In terms of magnitude, the estimated marginal effect of professional referees on second half injury time in the Premier League compared to First Division is 0.633 in column (i), 0.591 in column (ii) and 0.593 in column (iii)—i.e. something in the order or 35 seconds; these estimates are consistent with favouritism being removed after the introduction of professional referees.

# 5 Conclusions

While existing literature has searched for favouritism in a number of principal-agent settings, we believe our paper is the first to examine the extent to which such behaviour may be controlled; in our case by financial incentives. The paper's main contribution is to present evidence consistent with such control. In so doing, we also complement existing evidence suggesting that soccer referees may exercise their discretion in ways that favour home teams; in our case, by presenting data from the top two divisions of English soccer. It is worth being clear that, in a multi-million pound high-profile sport like soccer, such favouritism is of more than academic interest: promotion, relegation, prize money for league placings and players' careers could all be at stake, in principle, if soccer games are not officiated to high standards of objectivity. Our results are therefore important in indicating that principals may control their agents by appropriate and, in some sense, intuitive means. Of course, they are also important in a growing literature that has highlighted the potential for favourisitsm in principal-agent relationships.

Our results raise the question of whether financial incentives could control favouritism which occurred on a larger scale than that we have found. As pointed out in the paper, the smaller extent of favouritism in England may be the result of similar social pressure to that identified by Garicano *et al.* (2004), with the difference that the presence of larger proportions of 'away' supporters (partially) offsets that applied by 'home' fans. It might be conjectured that, in this slightly more 'even' setting, referees may not need significant additional incentives to alter their behaviour. As such, the financial incentives associated with becoming professional were sufficient. It would be interesting to see whether larger examples of favouritism can be controlled in a similar way; unfortunately, we are unaware of natural exper-

iments like the one we study in countries where soccer referees appear to exhibit more favouritism.

An interesting question raised by our results is the extent to which professional referees have increased welfare in English football. Of course, to the extent that home teams now receive less 'favours' from referees, we have not identified a Pareto improving policy. However, one might argue that some of the costs of tackling favouritism identified by Prendergast and Topel (1996) are not present in our setting. In particular, because referees negotiated the professional package before signing up to it, a revealed preference argument might suggest that they have been compensated for the loss of welfare associated with being less able to exercise discretion. If so, then the wider benefits of impartiality and objectivity that we have identified might be said to imply a positive welfare effect from professional referees.

We note that our results could be further strengthened by data on referees' earnings outside football (which would influence the opportunity cost of being removed from the professional referees' list) and on referees' individual characteristics. Perhaps understandably, referees and their professional association, are protective of such data and we have (so far) been unable to generate consistent observations for such controls.

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Table 1A: DESCRIPTIVE STATISTICS FOR PREMIER LEAGUE SAMPLE

| Variable | Obs. | Mean | Standard Deviation | Min | Max |
|---|---|---|---|---|---|
| Score difference | 760 | 0.461 | 1.721 | -6 | 8 |
| Score home | 760 | 1.586 | 1.289 | 0 | 8 |
| Score visitor | 760 | 1.125 | 1.098 | 0 | 6 |
| Goals scored in injury time 1st half home | 760 | 0.036 | 0.185 | 0 | 1 |
| Goals scored in injury time 2nd half home | 760 | 0.068 | 0.258 | 0 | 2 |
| Goals scored in injury time 1st half visitor | 760 | 0.015 | 0.119 | 0 | 1 |
| Goals scored in injury time 2nd half visitor | 760 | 0.041 | 0.198 | 0 | 1 |
| Minutes injury time 1st half | 760 | 1.796 | 1.022 | 0 | 14 |
| Minutes injury time 2nd half | 760 | 2.822 | 1.050 | 0 | 9 |
| Yellow cards home | 760 | 1.393 | 1.207 | 0 | 5 |
| Yellow cards visitor | 760 | 1.838 | 1.352 | 0 | 7 |
| Red cards home | 760 | 0.063 | 0.259 | 0 | 2 |
| Red cards visitor | 760 | 0.120 | 0.337 | 0 | 2 |
| Total player substitutions | 760 | 3.993 | 1.303 | 0 | 6 |
| Attendance (000's) | 760 | 33.114 | 11.099 | 8.248 | 67.721 |
| Attendance/Capacity | 760 | 0.896 | 0.119 | 0.314 | 1.038 |
| | | | | | |

*Note*: A maximum value for attendance/capacity greater than one is due either to a combination of heterogeneous data sources or to ground improvements over the season. In fact, Southampton and Watford are the only teams in our Premier League data with reported attendances at some games greater than the ground capacity.

Table 1B: DESCRIPTIVE STATISTICS FOR FIRST DIVISION SAMPLE

| Variable | Obs. | Mean | Standard Deviation | Min | Max |
|---|---|---|---|---|---|
| Score difference | 1104 | 0.389 | 1.637 | -6 | 6 |
| Score home | 1104 | 1.509 | 1.222 | 0 | 7 |
| Score visitor | 1104 | 1.120 | 1.114 | 0 | 7 |
| Goals scored in injury time 1st half home | 1104 | 0.058 | 0.238 | 0 | 2 |
| Goals scored in injury time 2nd half home | 1104 | 0.075 | 0.267 | 0 | 2 |
| Goals scored in injury time 1st half visitor | 1104 | 0.039 | 0.194 | 0 | 1 |
| Goals scored in injury time 2nd half visitor | 1104 | 0.050 | 0.218 | 0 | 1 |
| Minutes injury time 1st half | 1104 | 2.233 | 1.189 | 0 | 14 |
| Minutes injury time 2nd half | 1104 | 3.203 | 1.187 | 0 | 10 |
| Yellow cards home | 1104 | 1.151 | 1.122 | 0 | 7 |
| Yellow cards visitor | 1104 | 1.647 | 1.295 | 0 | 7 |
| Red cards home | 1104 | 0.066 | 0.273 | 0 | 2 |
| Red cards visitor | 1104 | 0.119 | 0.363 | 0 | 2 |
| Total player substitutions | 1104 | 4.024 | 1.273 | 0 | 6 |
| Attendance (000's) | 1104 | 14.793 | 7.093 | 0.849 | 33.027 |
| Attendance/Capacity | 1104 | 0.655 | 0.202 | 0.032 | 1.047 |
| | | | | | |

*Note*: A maximum value for attendance/capacity greater than one is due either to a combination of heterogeneous data sources or to ground improvements over the season. In fact, Portsmouth, Walsall, Crewe and Fulham are the only teams in our First Division data with reported attendances at some games greater than the ground capacity.

Table 2: Regression estimates of the impact of professional referees on second half injury time in the Premier League

| Independent variable | (i) | (ii) | (iii) | (iv) |
|---|---|---|---|---|
| | | | | |
| Constant | 3.251*** | 3.172*** | 2.248*** | 2.290 |
| | (0.091) | (0.126) | (0.207) | (1.935) |
| Score difference | -0.300*** | -0.516*** | -0.503*** | -0.531*** |
| | (0.120) | (0.166) | (0.159) | (0.191) |
| Year | | 0.159 | 0.079 | 0.214 |
| | | (0.178) | (0.172) | (0.419) |
| Score difference × Year | | 0.435* | 0.398* | 0.456* |
| | | (0.235) | (0.226) | (0.263) |
| Yellow cards | | | 0.092*** | 0.106** |
| | | | (0.037) | (0.044) |
| Red cards | | | -0.012 | -0.044 |
| | | | (0.132) | (0.152) |
| Player substitutions | | | 0.208*** | 0.200*** |
| | | | (0.044) | (0.054) |
| | | | | |
| Referee Fixed effects | No | No | No | Yes |
| Team Fixed effects | No | No | No | Yes |
| | | | | |
| $R^2$ | 0.02 | 0.06 | 0.15 | 0.32 |
| Observations | 311 | 311 | 311 | 311 |
| | | | | |

*Notes:* The dependent variable is the length of injury time in games that ended with a 1 goal difference. Score difference is equal to 1 if the home team is ahead by 1 goal before injury time begins, and 0 if it is behind by 1 goal. ***, ** and * denotes statistical significance at the 1 per cent, 5 per cent and 10 per cent levels respectively. Standard errors are in parentheses. The regression in column (iv) include controls for turnover of clubs, table rankings of home teams, the absolute value of the difference in ranks, attendance, ratio of attendance to capacity and monthly dummies.

Table 3: Injury time in close matches before and after professional referees

| | Pre-Professional Referees | Post-Professional Referees | Difference |
|---|---|---|---|
| | | | |
| Injury time first half | | | |
| | | | |
| Premier League | 1.926<br>(0.109) | 1.721<br>(0.059) | -0.205<br>(0.125) |
| First Division | 2.167<br>(0.074) | 2.373<br>(0.073) | 0.206<br>(0.104) |
| Difference-in-Difference | | | -0.411<br>(0.163) |
| | | | |
| | | | |
| Injury time second half | | | |
| | | | |
| Premier League | 2.874<br>(0.095) | 3.284<br>(0.069) | 0.410<br>(0.117) |
| First Division | 3.083<br>(0.072) | 3.806<br>(0.081) | 0.724<br>(0.108) |
| Difference-in-Difference | | | -0.314<br>(0.159) |
| | | | |

*Notes:* The sample includes games in which either the first half or second half ended with a 1 goal difference before injury time begins. Standard errors are in parentheses. The pre-Professional period is 1999-00 season. The post-Professional period is 2002-03 season. Some differences do not quite sum because of rounding.

Table 4: Marginal effect of professional referees on second half injury time: Premier League versus First Division

| Independent variable | (i) | (ii) | (iii) |
|---|---|---|---|
| | | | |
| Premier League | 0.245<br>(0.214) | 0.202<br>(0.223) | -0.107<br>(0.301) |
| Score difference | -0.097<br>(0.156) | -0.140<br>(0.154) | -0.166<br>(0.161) |
| Year | 0.834***<br>(0.182) | 0.761***<br>(0.178) | 0.625***<br>(0.244) |
| Premier League × Score difference | -0.417*<br>(0.235) | -0.387*<br>(0.229) | -0.349<br>(0.238) |
| Premier League × Year | -0.654***<br>(0.266) | -0.686***<br>(0.260) | -0.560<br>(0.361) |
| Score difference × Year | -0.233<br>(0.221) | -0.249<br>(0.215) | -0.208<br>(0.222) |
| Premier League × Score difference × Year | 0.633**<br>(0.332) | 0.591*<br>(0.324) | 0.593*<br>(0.336) |
| | | | |
| | | | |
| Referee Fixed Effects | Yes | Yes | Yes |
| Team Fixed Effects | No | No | Yes |
| | | | |
| $R^2$ | 0.29 | 0.33 | 0.38 |
| Observations | 763 | 763 | 763 |
| | | | |

*Notes:* The dependent variable is the length of injury time in games that ended with a 1 goal difference. Score difference is equal to 1 if the home team is ahead by 1 goal before injury time begins, and 0 if it is behind by 1 goal. ***, ** and * denotes statistical significance at the 1 per cent, 5 per cent and 10 per cent levels respectively. Standard errors are in parentheses. The regressions in columns (ii) and (iii) include controls for yellow cards, red cards, substitutions, table rankings of home teams, the absolute value of the difference in ranks, and attendance.