

# Penalties Before or After Extra-Time? An Empirical Assessment of Footballers' Incentives<sup>1</sup>

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## Abstract

The penalty shoot-out in football (soccer) has long been seen as problematic, among other reasons because it creates incentives for excessively cautious play during the preceding extra-time. One proposal to alleviate such incentives has been to alter the timing, and stage the shoot-out *before* (rather than after) extra-time with the result binding only if the subsequent extra-time offers no resolution. Carrillo's (2007) theoretical model examines the outcomes of such a rule change, and shows that since the effect is ambiguous in theory, the proposal's desirability needs to be assessed empirically. Our study attempts to do so. Using a comprehensive match data set we compare scoring outcomes of various treatment and control groups, whereby the former simulate closely players' incentives from the proposed rule change, and the latter represents the current rule. Most importantly, we examine how extra-time scoring probabilities depend on whether or not there was a goal in the first five (or fifteen) minutes of extra-time. We use three different objective functions for the comparisons, and simple statistical tests as well as logit regressions that control for a number of match-specific factors. Our estimates suggest that bringing the shoot-out before extra-time would substantially alter the players' incentives in extra-time, and produce more overall attacking play. Quantitatively, the rule change is predicted to increase the *odds* of extra-time scoring about three-fold. Specifically, for competitions such as the FIFA World Cup and the UEFA club competitions the *probability* of scoring in extra-time is estimated to increase on average by 45-60%, depending on various factors such as the result in regulation time, balancedness of the teams, and home ground advantage. The proportion of goal-less extra-times would therefore approximately fall by half: from almost 50% currently to below 25%. In summary, all our results suggest that the case for trialling the proposed rule is strong.

**Keywords:** incentives; sports economics; football; penalty shoot-out; logit regression

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## 1 Introduction

Despite football's unrivalled position as the World's most popular sport, its low-scoring nature creates the problem of finding a guaranteed winner in knock-out style tournaments, such as the International Football Association (FIFA) World Cup – the largest single sporting event in the World. Penalty shoot-outs, first sanctioned formally by FIFA in 1970,<sup>5</sup> were seen as a way of mitigating the need for a full replay requiring tournament rescheduling. However, shoot-outs are still deeply unpopular with some fans because of their numerous vagaries. These include the perception that the outcome it generates is merely a lottery rather than a true separation of quality; that it puts undue pressure on a small subset of players rather than the team; and that the game does not end in open play. Most importantly from an economics point of view, the shoot-out's existence seems to create undesirable incentives for excessively cautious and defensive play in the preceding extra-time.<sup>6</sup> This conundrum was summed up succinctly by none other than FIFA President Sepp Blatter, who said in September 2006: *'When it comes to the World Cup finals it is passion, and when it goes to extra-time, it is a drama. But when it comes to penalty kicks, it is tragedy.'*

Several proposals have been put forward to alter footballers' incentives in extra-time, and hence alleviate the 'tragedy' associated with the penalty shoot-out. One prominent proposal has been to stage the shoot-out *before* rather than after extra-time, with the shoot-out result binding only in the event that the subsequent extra-time fails to resolve the deadlock.<sup>7</sup> The shoot-out would thus play a similar role to an away-goal in two-leg series.

The proposal is examined carefully in a theoretical model by Carrillo (2007). He shows that whether or not the proposed rule change increases the total amount of offensive play (and the probability of scoring in extra-time) depends on the relative magnitude of two effects: the shoot-out loser playing more offensively and the winner playing more defensively. He concludes that the proposal's desirability in terms of which of these two effects is stronger remains an empirical issue that *'can only be answered by looking at the data.'*

Our paper provides empirical estimates of the proposed rule change compared to the current rule. We use a unique data set of football matches from various recent international and domestic competitions containing detailed information, including the exact minute of goals and bookmakers' odds. We consider three different objective functions discussed by Carrillo (2007), and in each case

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<sup>5</sup> See FIFA (2009), pp50-51 for a technical summary.

<sup>6</sup> This is partly due to the fact that players may tend to over-estimate the probability of their team winning the penalty shoot-out, see Carrillo (2007).

<sup>7</sup> Other mechanical details of the proposal are also non-trivial, such as whether to shorten the shoot-out to three spot kicks each or even immediate sudden-death. Doing so would prevent players from cooling down too much prior to extra-time, however, it also makes the result of the shoot-out even more arbitrary still. Other second-order effects may also arise, such as a higher penalty conversion rate due to the lower pressure factor. Nevertheless, our results relate solely to the timing of the penalty shoot-out and are hence applicable to any shoot-out format deemed desirable.

compare a control group in which the playoff series (one or two leg) is tied at a certain minute of the deciding game, to a treatment group in which one team is one goal ahead on aggregate (possibly only using the away goal rule). These groups closely simulate the teams' incentives from the current and proposed rule respectively.

We first focus on a sample of over 400 games that went into extra-time, as these are the games to which the rule would have been applied to if it had been adopted. We examine if/how the total amount of offensive play in extra-time - measured by observed scoring outcomes - depends on whether a goal was scored in the first five minutes of extra-time. The reason for this approach is that under current rules conceding a goal in the first few minutes of extra-time means that the team in question must score at least once in the remainder of extra-time, otherwise they will be eliminated. Therefore, the incentives on offer are similar to those provided by the proposed rule change.

We compare the treatment group (in which an early extra-time goal was scored) and the control group (no early goal) initially via simple sample statistics: chi-square or *t* tests. We then use logit regressions that enable us to control for other factors such as home ground advantage, the 'momentum' effect, unbalancedness of the teams, round and number of legs of the series.

Our estimates indicate that the rule change would have a sizable effect on players' incentives in the desired direction of promoting more attacking play and goal scoring. Quantitatively, it is predicted that the odds of scoring in extra-time would increase approximately three times. In competitions such as the FIFA World Cup and UEFA club competitions, the probability of at least one extra-time goal would rise on average by approximately 45-60% - depending on the specifics of the game/series. Most importantly, the highest marginal increases occur for: (i) low scoring games (i.e. one without a 'momentum' effect); (ii) with evenly balanced teams (i.e. no favourite); and (iii) played on neutral ground (i.e. without the home ground advantage). This is because a scoring momentum, lack of competitive balance, and home ground advantage already produce more attacking and scoring under the current rule, hence the proposed rule change is a partial substitute for these characteristics.

To demonstrate point (i), let us depict a FIFA World Cup game at the quarter-final stage, played by equally balanced teams based on the bookmakers' odds. According to our estimates, under the new rule the probability of scoring in extra-time for a game tied at 0:0 after regulation time would rise from about 0.35-0.37 to 0.59-0.62, which is a 59-76% increase. In contrast, for the same type of game tied at 3:3 after regulation time, the extra-time scoring probability would increase from 0.68-0.70 to 0.86-0.99, which constitutes a 27-42% marginal effect. Such increases in scoring probabilities would lead to a smaller proportion of games with the shoot-out outcome binding - especially in two-leg series. Overall, the proposed rule would approximately halve the proportion of score-less extra-times.<sup>8</sup>

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<sup>8</sup> At the same time fans that like to see (non-binding) shoot-outs would also be pleased as their incidence would increase under the proposed rule.

Anecdotally, the 2006 World Cup semi-final provides a famous epitome of our result, where (traditionally defensive) Italy seemingly attacked at all costs in extra-time against Germany, providing a most entertaining thirty minutes. Arguably, their abysmal relative past shoot-out record conditioned Italian tactics as if they had already lost a pre-extra-time shoot-out.<sup>9</sup>

As a robustness check, we also examine the difference between the treatment and control groups over the second half of extra-time only, as well as various periods of regulation time of all deciding knock-out matches (e.g. over the second half or last thirty minutes). We find that the incentives effect is still present (albeit with a lower magnitude for regulation time), which implies that the direction of the impact of the rule change is robust to the match interval under investigation.

In addition to the main ‘incentive’ result, our analysis also provides related insights of interest to sports economics researchers. For example, we report estimates of: (i) the advantage of playing at home; (ii) the scoring momentum effect; and (iii) the differences in scoring probabilities based on a measure of competitive balance of the teams derived from the bookmakers’ odds.

## 2 Related Literature

Our paper relates to several existing streams of research. The effect of rule changes in sport on individual player and team behavior has been analysed extensively, with applications as far ranging as perverse incentive effects to lose, to refereeing decisions, to drugs in sport policy. One specific branch of this work is the significant volume on playing mixed-strategies, see e.g. two applications relating to penalty shoot-outs: Chiappori, Levitt and Groseclose (2002) and Palacios-Huerta (2003).

Much of the early work in sports economics centres on the moral hazard effects arising from the ‘designated-hitter’ rule in Major League Baseball. This rule provides a very rare example of a natural experimental framework in which incentives induced by a playing rule can be tested, since the rule was introduced in the American League in 1973, but not in the National League, yet the two leagues are highly comparable in all other aspects. Among the more significant contributions are those by Goff, Shughart and Tollison (1997, 1998), and Bradbury and Drinen (2006), who show that the rule produces a higher rate of hit batters.

Similar literature relating to football, however, is somewhat sparser. Guedes and Machado (2002) estimate the effectiveness of increasing the value of a win from two to three competition points as a means of inducing more attacking play, using data before and after the rule change. Meanwhile, Haugen (2008) notes the implications of the rule on competitive balance of leagues.

On the specific issue of incentives in extra (or over-) time, some analysis has been undertaken on incentives caused by the allocation of competition points in tournament design, with primary reference to Ice Hockey’s National Hockey League. The collective works, such as Longley and Sankaran

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<sup>9</sup> In major international competitions, Germany’s past penalty shoot-out win/loss ratio had been 71%, whereas Italy’s only 20%, for more details see [www.penaltyshootouts.co.uk/countries.html](http://www.penaltyshootouts.co.uk/countries.html).

(2005) and Banerjee, Swinnen and Weersink (2007), focus on the introduction of extra-time and the incentives of the points system in creating attacking and defensive play. The papers show that the introduction of awarding one point for an extra-time loss (compared to zero previously) and two points for a win, predictably generated more attacking play in extra-time, but more defensive play in the latter stages of regulation time.<sup>10</sup>

There has also been some attempt at identifying similar aspects in football - Brocas and Carrillo (2004), in addition to the three-point issue, also examine the effect of the sudden-death element of extra-time (also known as 'golden goal'), while Banerjee and Swinnen (2004) approach the problem from a theoretical angle. Analogously, Ridder, Cramer and Hopstaken (1994) present a probability model estimating the marginal effect of the expulsion of a player (reducing the team to ten players), also an event likely to make the team play more defensively, on a team's likelihood of winning.

It will become apparent that our findings in the rest of the paper contribute to several streams of the literature mentioned above, both in sports economics and in microeconomics more broadly.

### **3 Data and Methodology**

Our dataset comes from a large database of over half a million football results kindly provided by [www.trefik.cz](http://www.trefik.cz). Of these games, there are close to one hundred and twenty thousand for which we have all the relevant information available including: (i) exact times of goals; and (ii) bookmakers' odds.<sup>11</sup>

The sub-sample we use in this paper consists of 3815 deciding matches in knockout stage playoffs, i.e. games that can potentially go into extra-time and penalties if drawn (on aggregate over the series). Of these games, approximately 70% come from the period 2007-2009, which is one of the strengths of the dataset. This is because the style of play and the amount of attacking has certainly evolved over time, and such recent observations will enable us to provide estimates relevant to the current style of play. Table 8 in Appendix 7.1 lists the covered competitions and the number of matches/series within each of them.

Section 4 reports several different ways of assessing the likely effects of the proposed rule change empirically, both in terms of the direction and magnitude. In each case we compare, at different times of the match, the differences in scoring outcomes between a treatment group simulating the proposed rule change, and a control group simulating the current rule. In order to be more precise in our discussion below, let us formally define several relevant concepts.

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<sup>10</sup> It is apparent that the proposed rule change we consider is unlikely to have such perverse effect on the play in regulation time as there is no reward for a tie.

<sup>11</sup> While we have odds by a number of bookmakers, for consistency we use only those of the three largest agencies in the Czech Republic, as they cover the whole considered period.

First, let a *decider* be a playoff game that concludes a series, i.e. the second leg in a two-leg series and the single game in a one-leg series. In order to better approximate the incentives of the proposed rule change, we limit throughout our attention to deciders, where we take into account the aggregate score of the series as well as the away goal rule. Second, denote  $M$  to be the *end of a certain minute or minute interval* of the decider. For example, M60 denotes the one hour mark, M90+ indicates regulation time including stoppage time ('+' throughout indicates the inclusion of stoppage time occurring after that minute), and M90+-120+ denotes extra-time. Third, define the *status quo* of a series at time  $M$  of the decider as either 1 (the home team leads on aggregate, possibly only on the away goals rule), -1 (the away team leads on aggregate, possibly only on away goals), and 0 (neither team leads, not even on away goals). Fourth, an *objective* will throughout refer to the criterion according to which the desirability of the proposed rule change (and the treatment and control groups) will be compared.

Using these definitions, the control group will throughout consist of deciders in which the status quo of the series at  $M$  is 0. In contrast, the treatment group games will always satisfy two conditions: (i) the status quo at  $M$  of the decider is either 1 or -1; and (ii) one goal for the trailing team changes the status quo of the series.<sup>12</sup>

Our main focus is on games in which extra-time was played, as this sample coincides with the games to which the rule change would have been applied had it been adopted. Further, as the teams are tied after M90+, they have demonstrated a high degree of homogeneity in terms of their quality, and hence we can be confident that the assignment into the treatment and control groups is largely random. We have 440 such games, about 85.5% of them one-leg and 14.5% two-leg series. While we use all of these in the simple statistical tests in Section 4.1, for the logit regressions in Sections 4.2-4.5 we use an unbiased sub-sample of 415 games for which we have betting odds data (for a break down of scoring outcomes and other statistics, see Tables 9 and 10 in Appendix 7.2). In particular, we are interested in whether/how an early extra-time goal (scored within the first five minutes) affects the scoring outcomes in the rest of extra-time. Nevertheless, to make sure the incentive effect is robust, we examine whether it is present at different stages of the game, for example over the second half of extra-time only (with cut-off M105+), the second half of regulation time (with cut-off M45+) or over the last half an hour of the regulation time (with cut-off M60).

In evaluating the proposed rule change several objectives seem plausible. Carrillo (2007) mentions the three most natural candidates: I. maximising the total amount of offensive play; II. maximizing the sum of the probabilities of scoring; and III. minimising the probability of deciding the winner by penalty shoot-outs. We believe that these objectives are, using the available data, best

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<sup>12</sup> An alternative would be to require that the status quo is not just changed but reversed fully. However, it would be arguably very stringent in one-leg games as it would require two goals scored by the trailing team. Since the payoff for scoring is lower under our specification than under the proposed rule change where one goal reverses the status quo fully, our estimates in this paper can be considered as a lower bound of the actual effect.

approximated in the following way. In terms of objective I, it is the mean or median number of goals over the period of interest. In terms of objective II, it is the proportion of games in which at least one goal is scored over the period of interest. In terms of objective III, it is the proportion of series in which the aggregate score is no longer tied at the conclusion of the period of interest.

There seem to be strong reasons favouring objective II over the other two for the purposes of our analysis. First, objective II best indicates the *proportion* of games in which attacking and scoring is high. A similar indicator is provided if we use the median for objective I, but the problem is that due to the low scoring nature of football games, the median is zero for all the sub-periods of the game we are interested in (second half onwards). A high mean in regards to objective I could possibly be driven by a small number of outlying (high scoring) games.

Second, when considering the treatment group under objective III we need to include an extra condition, namely that at least one additional extra-time goal is scored after the first M90<sup>+</sup>-95 goal. This is to make sure that our results are not driven by the selection criterion itself, and overstate the treatment group effect. However, it needs to be remembered that this technical requirement does not reflect the nature of the proposed rule change.

Third and most importantly, for one-leg playoffs objective III excludes games in which both teams score the same number of goals in the considered period. As such, it conceals a significant part of the improved incentives effect and increase in overall attacking play. For two-leg series in which the away goal rule applies, objectives II and III are obviously equivalent in terms of extra-time, since once a goal is scored the aggregate score (taking into account away goals) can no longer be tied.

Given that under the proposed rule change this equivalence of objectives II and III would be true for both one-leg and two-leg series, the latter seems less desirable for the evaluation of the new rule. For these reasons, while our simple statistical comparisons of the treatment and control groups examine all three objectives, our logit regressions focus exclusively on objective II.

## 4 Empirical Results

Our main focus is on scoring outcomes in extra-time. We first examine them depending on whether or not a goal was scored in: (i) the first five minutes of extra-time, i.e. M90<sup>+</sup>-95 (Sections 4.1-4.3); and then (ii) in the first 15+ minutes of extra-time, i.e. M90<sup>+</sup>-105<sup>+</sup> (Section 4.4). For this purpose we use all games in our sample in which extra-time was played, both one and two-leg series. As a further robustness check, we also examine scoring outcomes in regulation time (Section 4.5).

In terms of capturing the effect of the rule change in extra-time, one possibility is to focus on the differences between the treatment and control groups over the subsequent 25+ or 15+ minutes of extra-time, i.e. M95-120<sup>+</sup> for (i) and M105<sup>+</sup>-120<sup>+</sup> for (ii). We use this method for exercise (ii). The disadvantage of this method, however, is the fact that games in which two early extra-time goals were scored are either excluded from both groups (if both goals are scored by the same team), or

'incorrectly' appear in the control rather than the treatment group in one-leg series (if each goal is scored by a different team). Therefore, to avoid this problem in specification (i) we use an alternative method and examine scoring outcomes over the entire duration of extra-time, M90+-120+, where for the treatment group the interval naturally begins the moment the first extra-time goal was scored. It should be acknowledged, however, that there is a slight overlap between the criterion for group selection and the effect period, and hence this method is not as 'clean' econometrically.<sup>13</sup>

We consider two main approaches in terms of the dependent variable implied by objective II. In Section 4.2 our dependent variable is *the probability that at least one team scores at least one goal in the period of interest* (e.g. extra-time). It will, however, be shown that such an 'overall' specification - not distinguishing between the teams - can hide some effects coming from each team that are offsetting each other. Therefore, our benchmark 'individual team' specification used in Sections 4.3-4.5 has the dependent variable as *the probability that one specific team (e.g. the home team) scores the first goal in the period of interest*. Obviously, the overall scoring probability in the latter case is simply the sum of the two individual ones. The same is (approximately) true for odds ratios, but not for the marginal effects since they are about percentage *changes* of the probability, not the probability levels. Therefore, the marginal effects are comparable across all the specifications below without any scaling.

#### 4.1 M95: Simple Comparisons

Table 1 provides the statistics for both the treatment and control group for all three objectives. It shows that there is a large statistically significant difference between the two groups across objectives I and II. In terms of objective I, the average number of goals in the treatment group is 69.9% higher relative to the control group.<sup>14</sup> In terms of objective II, the proportion of games in which there was at least one goal during extra-time (not counting the first goal of the treatment group) is 59.8% higher in the treatment group relative to the control group. In terms of objective III, the marginal effect is 28.4% and statistically insignificant, but we will see below that this is due to the overly stringent requirement of an additional extra-time goal discussed above.

It may be informative to consider which team scores the second extra-time goal - in matches with more than one extra-time goal. In this sample, in approximately 57% of such cases it was the team that scored the first extra-time goal, and in 43% it was the opponent. Due to the small number of such matches this difference is statistically insignificant. This seems to (tentatively) suggest that the

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<sup>13</sup> The results of the two methods for exercise (i) are very similar because: 1) the overlap is on average around 2 minutes, which is negligible relative to the non-overlapping period of 25+ minutes; and 2) there are only four games with two early extra-time goals in our sample.

<sup>14</sup> Let us mention that 14 games in the sample were ended by a golden or silver goal. Table 1 makes no adjustment for this fact, but we re-calculated the statistics making an appropriate normalization using games to which the golden/silver goal rule did not apply. Since the average number of goals in both the treatment and control groups increases similarly, the proportional difference between the groups remains virtually identical.



proposed rule change would not excessively advantage the team that won the penalty shootout, but leave the winner of the game to be determined in the subsequent extra-time.

TABLE 1: Simple Comparisons for All Objectives

		Treatment group	Control group
	Number of games	48	392
	Proportion of the total	10.9%	89.1%
	Proportion of one-leg series	89.6%	85%
Objective I	Average number of goals in extra-time (excluding the first goal in M90 <sup>+</sup> -95, if any)	1.188	0.699
	Standard deviation	1.024	0.879
	Independent two sample (two-tailed) <i>t</i> -test <i>p</i> -value	0.002	
	<b>Marginal effect</b>	<b>69.9%</b>	
Objective II	Number of games with at least one goal in extra-time (excluding the first goal in M90 <sup>+</sup> -95, if any)	36	184
	Proportion of games with at least one goal in extra-time (excluding the first goal in M90 <sup>+</sup> -95, if any)	75%	46.9%
	Chi-Square test <i>p</i> -value	0.0002	
	<b>Marginal effect</b>	<b>59.8%</b>	
Objective III	Number of games in which the extra-time resolves the tie, and there is at least one goal scored (excluding the first goal in M90 <sup>+</sup> -95)	25	159
	Proportion of games in which the extra-time resolves the tie, and there is at least one goal scored in M95-120 <sup>+</sup>	52.1%	40.6%
	Chi-Square test <i>p</i> -value	0.127	
	<b>Marginal effect</b>	<b>28.4%</b>	

While informative about the direction of the proposed rule change, such simple comparisons could potentially be misleading as they do not account for various important factors that may be driving them. Therefore, to have confidence in the magnitude of the effect the rest of the paper estimates it using logit regressions including a number of control variables. This will enable us to separate the incentive effect from other relevant factors.

#### 4.2 M95: Logit Model with Overall Probability of Scoring

The description of the dependent and independent variables used in this section's logit regression is provided in Table 2 (generally G will throughout stand for 'goal'). The table also reports the summary statistics of all the variables, and the fact that we have 415 observations for this specification (in contrast to the previous section in which odds are not used).

Let us mention several relevant issues. The dependent variable, GPROB, refers to *any* goal scoring without distinguishing which teams scores. RULEΔ is the critical parameter, as a significantly positive (negative) estimate implies that an early extra-time goal raises (reduces) the overall level of attacking and the probability of scoring. This parameter thus approximates the effect of the proposed rule change.

The other variables are included to control for certain characteristics of the match/series. Most of them are natural: (i) whether the game was played on neutral ground (NEUT); (ii) whether it was an international or domestic competition (INTL); (iii) which round (stage) of the tournament it occurred (ROU); and (iv) whether it was a one-leg or two-leg series (LEGS).

TABLE 2: Definitions and Summary Statistics of Included Variables

Variable	Variable description	# of Obs	Mean	Standard deviation	Min	Max
<b>GPROB</b>	Dependent variable, the probability of goal scoring by any team in the period of interest	415	0.513	0.500	0	1
<b>RULEΔ</b>	Treatment/control group dummy indicating the (aggregate) goal difference at the start of the period of interest: 0=control; 1=treatment group	415	0.113	0.317	0	1
<b>GRATE</b>	A (game) ‘momentum’ dummy: the sum of goals scored in the series prior the extra-time (in two-leg series normalized per game)	415	1.605	1.628	0	8
<b>INTL</b>	Type of game dummy: 0=domestic; and 1=international games (the latter includes both the national team level and club level)	415	0.181	0.385	0	1
<b>ROU</b>	The stage of the tournament: 0=lower rounds; 1=round of 16; 2=quarter-final; 3=semi-final; 4=final	415	0.834	1.266	0	4
<b>LEGS</b>	The type of series dummy: 0=one-leg; 1=two-leg series	415	0.154	0.362	0	1
<b>NEUT</b>	Neutral site dummy: 0=no; 1=yes	415	0.133	0.339	0	1
<b>UNBAL</b>	Measure of unbalancedness of the series using bookmakers’ odds: for computation see (1)	415	0.826	0.646	0	2.823

The remaining two control variables are less obvious but more interesting. GRATE is included as a means of controlling for the scoring or game momentum. In particular, it expresses excess of attacking play over defensive play prior to the period of interest (regulation time), as this scoring momentum is likely to continue into the period of interest (extra-time) as well.<sup>15</sup> In contrast, UNBAL captures the ‘uncertainty of outcome’ or ‘competitive balance’ of the contest – considered to be a crucial element in sports economics and behavioral economics that conditions the choices of attacking and defensive strategies of teams, see Guedes and Machado (2002), Easton and Rockerbie (2005) and Haugen (2008).

The UNBAL measure is computed as the absolute value of the natural logarithm of the teams’ relative winning probabilities, which are derived from the bookmakers’ odds:

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<sup>15</sup> We will in Section 4.3 discuss a variable expressing a ‘team momentum’ as opposed to the ‘game momentum’.

$$\text{UNBAL} = \text{absolute value} \left( \ln \left( \frac{\text{probability of team 1 'win'}}{\text{probability of team 2 'win'}} \right) \right) \quad (1)$$

'Win' refers to the team going through to the next round, or securing the trophy in the final. In terms of one-leg series we use the odds relating to the result in regulation time (M90+). In terms of two-leg series we use the 'go-through' odds where available (about half of the series), and where unavailable we determine these from the odds of the first leg using a simple regression model.<sup>16</sup> Our specification implies that a higher UNBAL measure describes more unbalanced teams as their probabilities of 'winning' differ more. Having described the variables, Table 3 reports the results of the logit regression.<sup>17</sup>

TABLE 3: Logit Results

Variable	Coefficient Estimate	p-value	Odds Ratio
<b>CONSTANT</b>	-0.727***	0.001	
<b>RULEΔ</b>	1.096***	0.002	2.992
<b>GRATE</b>	0.228***	0.001	1.256
<b>INTL</b>	0.181	0.624	1.198
<b>ROU</b>	0.211*	0.058	1.235
<b>LEGS</b>	0.013	0.972	1.013
<b>NEUT</b>	-0.489	0.323	0.613
<b>UNBAL</b>	0.197	0.217	1.218
<b>Log-Likelihood</b>			
	-273.121		
<b>Cragg-Uhler Pseudo-R<sup>2</sup></b>			
	0.089		
<b>Prediction rate</b>			
	57.6%		

Note: \*, \*\*, and \*\*\* denote statistical significance at the 10%, 5%, and 1% level respectively.

In terms of overall explanatory power of the regression expressed by the pseudo-R<sup>2</sup>, it is 'comparable' to logit models estimated in the literature.<sup>18</sup> Regression results using sports data broadly provide relatively low fit because of the general unpredictability of outcomes of sporting contests – a property of the data that helps explain the wide interest in sports by the general public, noted as far back as Rottenberg (1956). In addition, the logit model is being fitted to two distinct points rather than a locus of points.

The interpretation of estimated coefficients in logit regressions is not straightforward, and we will henceforth report the magnitudes of various effects in two different ways. Firstly, the change in the *odds*, indicated by the 'odds ratio' in the last column of Table 3. Formally, if we denote  $\tau$  and  $\gamma$  to

<sup>16</sup> We fit a simple linear regression from the first leg probabilities. The correlation coefficient of 0.97 suggests it is a good way of doing so.

<sup>17</sup> Let us mention the related issues. First, another variable of interest would be the presence of red cards in the game. As our sample only has this information for a minority of games, we cannot control for this feature in our regressions. Second, we have also estimated probit regressions but the results are very similar to the reported logits.

<sup>18</sup> It must be emphasized that one cannot directly compare various pseudo-R<sup>2</sup> statistics across different models/specifications, or with the standard R<sup>2</sup>, since their nature differs.

be the scoring probabilities of the treatment and control groups respectively, the odds ratio is defined as  $\frac{\tau/(1-\tau)}{\gamma/(1-\gamma)}$ . Secondly, the ‘marginal effect’ is commonly used for such purposes, which is the percentage change in the scoring *probabilities*, defined as  $\tau/\gamma - 1$ .

The advantage of the odds ratio is that it comes out directly from the logit regression, and it does not depend on values of other variables. On the other hand, the marginal effect is simpler and more intuitive, but it is not related directly to the logit regressions. Furthermore, it depends on the combination of all the other variables, and as such it is less general. We will use both below.

Turning to the estimates in Table 3, we see that the key variable *RULEΔ* is positive and significant, and its magnitude is quite large in comparison to the other coefficients. This implies that an early goal in extra-time substantially increases the total amount of attacking play and the probability that at least one goal will be scored subsequently. Specifically, the odds ratio statistic implies that such an early goal triples the odds of subsequent scoring in extra-time.

In terms of the more intuitive marginal effects, we report specific examples in Tables 11-12 in Appendix 7.3. They relate to two major types of international competitions, namely the FIFA World Cup and the UEFA European Champions League. In each case, we report the marginal effects relevant to different regulation time scores, the quarter-final leg, and two different UNBAL levels (even teams and a 2:1 favourite). The tables show that the marginal effect is positive for all regulation time scores. Its weighted average (with weights being the proportion of each score from Table 9) is 60.8% and 55.3% for the World Cup with even teams and 2:1 favourite respectively. The respective numbers for the UEFA club competitions are 59.8% and 54.3%. Let us point out that these results are in line with the simple statistics presented in Table 1.<sup>19</sup>

Additional interesting results emerge regarding partial substitutability of the proposed rule change with the momentum and unbalancedness of the teams. First, Tables 11-12 show that the marginal effect decreases with regulation time scoring, and is hence the highest for goal-less matches after M90+. This can be interpreted as scoring (or game) momentum: high scoring during regulation time predicts high scoring in extra-time, hence there is less need to improve the incentives of players in that type of match.<sup>20</sup> Such need is greatest for low scoring games, which form a large proportion of all games (see Table 9). This result can more clearly be seen through the coefficient on *GRATE*, which predicts that every additional goal in regulation time leads to an increase in the extra-time scoring odds ratio by 26%.

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<sup>19</sup> Note that unlike the marginal effects (i.e. *percentage increases* in the probability) that differ across the two competitions and the two unbalancedness levels, the *level* of the scoring probability increases by about 0.25 in all cases.

<sup>20</sup> Intuitively, a goal is likely to increase the confidence of the scoring team, but also momentarily reduce its concentration, whereas for the conceding team a goal provides distress as well as an impulse to try harder. All these circumstances are likely to increase the probability of goal scoring for a given status quo of the game.

Second, there is a negative relationship between the marginal effect and the UNBAL measure. Intuitively, one team being favoured is likely to increase the scoring probability under the current rule for both groups, as the favourite tends to try to use its perceived superiority to decide the game in extra-time rather than leaving it to the penalty shoot-out. Therefore, the proposed rule change would have a slightly lower marginal effect in such games as opposed to very even teams that play more cautiously in extra-time and are more likely to rely on the penalty shoot-out.<sup>21</sup> This contradicts the implication of Table 3 in which UNBAL is insignificant, which would suggest at face value that uncertainty of outcome does not play a role. It must, however, be remembered that given our specification for UNBAL in equation (1), there are two different effects that are potentially offsetting each other (due to the absolute value) – that of the favourite against that of the underdog. Such inability of the ‘overall’ specification of the dependent variable in this section to disentangle the effects from each team’s perspective implies that an alternative specification may offer a more accurate assessment of the rule change. Therefore, in the remainder of the paper we ‘split’ the dependent variable and consider the scoring probability for each team separately, which enables us to study the home advantage as well.

In terms of the other variables, ROU is found to be significantly positive at the 10% level, but our results below indicate that the significance of the round is not robust. The other remaining dummies are all statistically insignificant implying that they do not play a major role in the determination of scoring.

#### 4.3 M95: Logit Model with Individual Team’s Probability of Scoring

The dependent variable in this section is no longer the overall scoring probability, but the probability that one team scores the first goal in extra-time (not counting the first goal in the treatment group). We highlight this by denoting it GPROB1T. This specification has three main advantages.

First, despite using the same sample of games the number of observations doubles as both teams’ perspectives are now included separately. Second, such refined specification will better account for competitive balance of the teams. To do so we replace the UNBAL variable by FAV (short for favourite), which is defined as follows:

$$FAV = \ln \left( \frac{\text{probability of the team's 'win'}}{\text{probability of the opponent's 'win'}} \right) \quad (2)$$

Third, a home-ground advantage dummy (HOME) can be included to estimate the benefit of a familiar environment (over and above the neutral site dummy and the information contained in FAV). This is desirable as a number of studies have showed it to play an important role, see, for example, Pollard (1986) and Clarke and Norman (1995).

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<sup>21</sup> For both competitions and any regulation time score, the marginal effect is about 10% lower for a 2:1 favourite scenario relative to evenly balanced teams.

Nevertheless, the specification of GPROB1T also has two minor disadvantages. First, the errors may be slightly correlated as there are two observations for each game with potentially common factors. For example, heavy rain is likely to affect both participating teams in a certain common way, which will transpire into the residuals of the regression. However, comparing the results of our various specifications will reveal that this issue is unlikely to play any major role. Second, as the overall scoring probability is obtained by doubling the individual team’s scoring probabilities, it is possible in principle that its estimate will (slightly) exceed 1 for very high scoring games.

The dependent and independent variables are summarized in Table 4, and the estimation results reported in Table 5. Given the nature of this regression we would expect the values of the parameters to be approximately half of those in Section 4.2, since the dependent variable is ‘split’ in two. The exceptions to this are the constant, the NEUT parameter likely to be affected by the inclusion of the new control variable HOME, and the re-specified variable UNBAL. Table 5 shows that these expectations are indeed met.

TABLE 4: Definitions and Summary Statistics of Included Variables

Variable	Variable description	# of Obs	Mean	Standard deviation	Min	Max
<b>GPROB1T</b>	Dependent variable, the probability of one team scoring the first goal in the period of interest	830	0.257	0.437	0	1
<b>RULEΔ</b>	As defined in Table 2	830	0.113	0.317	0	1
<b>GRATE</b>	As defined in Table 2	830	1.605	1.627	0	8
<b>INTL</b>	As defined in Table 2	830	0.181	0.385	0	1
<b>ROU</b>	As defined in Table 2	830	0.834	1.265	0	4
<b>LEGS</b>	As defined in Table 2	830	0.154	0.361	0	1
<b>NEUT</b>	As defined in Table 2	830	0.133	0.339	0	1
<b>FAV</b>	Measure of unbalancedness of the series using bookmakers’ odds: for computation see (2)	830	0.000	1.048	-2.823	2.823
<b>HOME</b>	Home ground dummy: 0=away team or neutral site, 1=home team	830	0.434	0.496	0	1

TABLE 5: Logit Results

Variable	Coefficient Estimate	p-value	Odds Ratio
<b>CONSTANT</b>	-1.712***	0.000	
<b>RULEΔ</b>	0.610**	0.013	1.840
<b>GRATE</b>	0.140***	0.005	1.151
<b>INTL</b>	0.110	0.711	1.117
<b>ROU</b>	0.126	0.142	1.134
<b>LEGS</b>	0.024	0.933	1.024
<b>NEUT</b>	-0.121	0.766	0.886
<b>FAV</b>	0.525***	0.000	1.690
<b>HOME</b>	0.321*	0.075	1.379
<b>Log-Likelihood</b>	-440.100		
<b>Cragg-Uhler Pseudo-R<sup>2</sup></b>	0.111		
<b>Prediction rate</b>	74.7%		

Let us first note the extremely high prediction rate of 74.7%, which refers to the percentage of games (from one team's point of view) that our estimated model can forecast correctly (using the 50% threshold). This rate is higher than comparable studies in the literature such as Stefani and Clarke (1992) and Winchester (2010), where it is commonly around 65-70%.

RULEA is still positive and significant at the 5% level. While the odds ratio is reduced, it must be remembered that the dependent variable is the individual probability, and hence the overall probability and odds ratio are comparable to those in Section 4.2. The marginal effects for the two major tournaments reported in Appendix 7.3, Tables 13-14, are also very similar, and in line with the simple statistics of Section 4.1. Furthermore, all other related findings apply here as well – the marginal effect: (i) is positive for all regulation time scores; and (ii) decreases with regulation time scoring as well as unbalancedness.

The new FAV variable is now highly statistically significant. This means that a shorter-price favourite would be even more likely expected to make their excess of class over their opposition count in extra-time (as demonstrated by Boyd and Boyd, 1995), and hence a higher probability of it scoring. FAV also implies the reason that UNBAL was not significant in section 4.2. If one team is the favourite and the other is the underdog, the aggregate sum of the effect may be close to zero as they offset each other.

The fact that our results are robust is further confirmed by the fact that all the other variables have the same sign as in Section 4.2, and those that were significant (GRATE) or insignificant (NEUT, LEGS, and INTL) remain so. The only variable with an altered significance is ROU: it is no longer statistically significant. This implies that once the home ground advantage is controlled for, the stage of the tournament does not seem to play a role.

In terms of the newly-introduced variable HOME, it is positive and statistically significant at the 10% level, predicting an increase in the odds ratio by 38%. This result is consistent with previous studies on home-ground advantage in football, such as Pollard (1986) and Clarke and Norman (1995). Let us mention, however, that this effect is over and above that already included in the bookmakers' odds.<sup>22</sup>

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<sup>22</sup> A different way of assessing the home ground advantage is to look at the proportion of games won by the home team relative to the away team. We have 127,161 football games in our sample that are *not* played on neutral ground. Of these, 42.6% were won by the home team and 25.4% were won by the away team (the rest were tied). According to these numbers, the away team's probability of winning would increase by 67.7% if it played at home rather than away. One should, however, make two important distinctions. First, for two-leg series it was shown that the size of the home ground advantage depends on the leg and is greater for the second one, see Page and Page (2007). Second, it should be distinguished between cup games (playoff stage) and league games (non-playoff). In each the incentives are obviously different due to a different reward system: in league games, the three points for a win and one point for a draw system arguably leads to less caution and more attacking play than in playoffs. This is consistent with the recent contribution of Dilger and Geyer's (2009) natural experiment comparing German League and Cup games (in a style similar to the framework advocated

We have also experimented with a ‘team momentum’ dummy, describing whether or not the relevant team scored the last goal prior to the period of interest. In all specifications the magnitude and significance of the *RULEA* dummy has not altered much. However, as the team momentum dummy was highly correlated with the game momentum variable *GRATE*, the *p*-value of the latter was reduced to around 10%. As we believe the game momentum is a more important force of the two, we have not reported the results with the team momentum dummy (they are available from the authors upon request).

#### 4.4 M105+: Logit Model with Individual Team’s Probability of Scoring

As a robustness check, this section examines a different (longer) period for the selection into the treatment and control groups, namely all of the first half of extra-time (15+ minutes). Furthermore, as explained above, unlike Sections 4.1-4.3 it uses the M105+ time as a fixed cut-off, and only examines the subsequent outcomes in the second half of extra-time. The dependent and independent variables are summarized in Table 6, and the estimation results, using 792 observations, are reported in Table 7.

TABLE 6: Definitions and Summary Statistics of Included Variables

Variable	Variable description	# of Obs	Mean	Standard deviation	Min	Max
<b>GPROB1T</b>	As defined in Table 4	792	0.199	0.400	0	1
<b>RULEA</b>	As defined in Table 2	792	0.265	0.442	0	1
<b>GRATE</b>	As defined in Table 2	792	1.626	1.521	0	9.429
<b>INTL</b>	As defined in Table 2	792	0.184	0.388	0	1
<b>ROU</b>	As defined in Table 2	792	0.823	1.262	0	4
<b>LEGS</b>	As defined in Table 2	792	0.154	0.361	0	1
<b>NEUT</b>	As defined in Table 2	792	0.136	0.343	0	1
<b>FAV</b>	As defined in Table 4	792	0.000	1.028	-2.776	2.776
<b>HOME</b>	As defined in Table 4	792	0.432	0.496	0	1

TABLE 7: Logit Results

Variable	Coefficient Estimate	<i>p</i> -value	Odds Ratio
<b>CONSTANT</b>	-1.928***	0.000	
<b>RULEA</b>	0.506**	0.014	1.659
<b>GRATE</b>	0.130**	0.035	1.138
<b>INTL</b>	0.052	0.876	1.053
<b>ROU</b>	0.094	0.325	1.099
<b>LEGS</b>	0.057	0.855	1.058
<b>NEUT</b>	-0.234	0.607	0.791
<b>FAV</b>	0.414***	0.000	1.512
<b>HOME</b>	0.091	0.644	1.095
<b>Log-Likelihood</b>	-376.631		
<b>Cragg-Uhler Pseudo-R<sup>2</sup></b>	0.075		
<b>Prediction rate</b>	80.3%		

here), and is confirmed by the statistics in our dataset. The average number of goals in regulation time of playoff games is 0.79 for home teams and 0.63 for away teams, whereas in league games the respective numbers are 1.44 and 1.04.



The results are broadly similar to those of Section 4.3, both in terms of the magnitude of the variables, and their statistical significance - with the prediction rate being even higher. There is one exception: the HOME dummy ceases to be significant. This seems to suggest that home ground advantage is not as useful in the second half of extra-time.

In terms of the incentive variable RULE $\Delta$ , there is still a large and statistically significant effect, with a similar magnitude. The weighted averages of the marginal effect analogous to those reported in Tables 13-14 are as follows: for the FIFA World Cup 54.5% and 46.0% under even teams and 2:1 favourite respectively, whereas for the UEFA club competitions these numbers are 48.2% and 44.5% respectively.

#### 4.5 The Incentive Effect in Regulation Time

The results of the previous sections suggest that the rule change would have a strong effect on the incentives of players in extra-time. As a further robustness check, we also carried out experiments on whether a narrow lead, as opposed to the game being tied, produces different player behavior and outcomes during regulation time.

We ran the logit regressions for a number of M cut-off specifications between M45+ and M75, in the same fashion as we do in Section 4.4.<sup>23</sup> The results of all these regulation time regressions are mutually comparable. Furthermore, all the variables have the same sign as the reported extra-time regression, and those that were or were not significant remain so.

In terms of the incentive effect, the RULE $\Delta$  variable is still positive and statistically significant at the 5% level. The magnitude of the incentive effect is however markedly lower in regulation time compared to extra-time. The odds ratios are in the range of 1.1-1.2, and the marginal effects for the FIFA World Cup and European Champions League are in the order of 7-10%.

One obvious reason for the latter with the M45+ specification is the fact that the scoring probability in the control group is much higher with more time (one whole half) remaining. Specifically, it is 0.64-0.83 on average for the two competitions, and hence any increase in the probability will constitute a smaller percentage. Nevertheless, this explanation does not apply to the M60-70 results.

Several alternative explanations for the lower incentive effect come to mind. First, unlike the RULE $\Delta$  dummy that is independent of the other variables and only contains information about the first 5 or 15+ minutes of extra-time, during regulation time it depends on other variables and relates to the whole match/series. Second, in extra-time the players are arguably more tired, so they are more likely to make mistakes. The 'conversion' of these mistakes into goals is likely to be greater if there is more

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<sup>23</sup> The sample size is obviously different for each M cut-off. For example, for M45+ it is 5050 observations (2525 series) and for M60 it is 4324 observations (2162 series).

attacking and defending (the treatment group), as a greater proportion of playing time happens closer to (or inside) the penalty areas. Third, less ‘immediacy’ of the goal separating the treatment group teams is another possible explanation. In extra-time the early goal immediately precedes the considered period, whereas in regulation time a potential separating goal may have been scored 45 minutes earlier, or even one/two weeks earlier if scored in the first-leg.

Fourth and most interestingly, one could hypothesise that the size of the incentive effect is decreasing in game time remaining. It seems plausible that as the end of the game is approaching the trailing team will have to take greater risks in trying to tip the game in its favour, which is likely to increase the probability of both the team’s scoring as well as its conceding. Nevertheless, this hypothesis does not seem to be confirmed in the data - the relationship between the size of the dummy and the cut-off  $M$  is not monotone with a clear pattern. This is the case not only in the considered cut-off range  $M_{45+}$  to  $M_{75}$ , but also in extra-time where the marginal effects for  $M_{105+}$  were similar to (in fact slightly smaller than for)  $M_{95}$ . More research is required to shed light on the reasons behind this, and identify which of the above explanations is most relevant.

## **5 Summary and Conclusions**

Sports data provide a valuable opportunity for empirical testing of hypotheses arising from theoretical analyses of games, incentives and strategies in economics. This paper empirically assesses whether and how players’ incentives depend on the sequencing of various tie-breaking components of the game. Specifically, following a recent proposal we investigate to what extent, if any, the amount of attacking and scoring would differ if the penalty shoot-out was brought from after extra-time to before extra-time. We do so using a unique dataset of recent football matches including detailed information such as the exact times of goals and bookmakers’ odds.

Our analysis suggests that such a rule change would generate substantial increases in the overall attacking level and scoring outcomes in the subsequent extra-time. Qualitatively, it is predicted that the rule change would increase the odds of scoring in extra-time about three-fold. In terms of the probabilities for competitions such as the FIFA World Cup and UEFA club competitions, the proportion of extra-times with at least one goal would increase, on average, by 45-60%. The proportion of goal-less extra-times would therefore approximately fall by half: from the current level of almost 50% to below 25%. The exact magnitude is shown to depend on various factors such as the result in regulation time, balancedness of the teams, and home ground advantage.

Our findings may also have implications for other low-scoring sports in which finding a victor is imperative for tournament design, such as field hockey and ice hockey. Given these findings, and additional beneficial features of the proposed rule change such as finishing the game as a team contest in open play, and alleviating the pressure and personal ‘tragedy’ of individual players, the case for testing this rule is strong.

## 6 References

- Banerjee, A. N. and Swinnen, J. F. M. (2004), "Does a Sudden Death Liven up the Game? Rules, Incentives, and Strategy in Football", *Economic Theory*, 23 (2), 411-421.
- Banerjee, A. N., Swinnen, J. F. M. and Weersink, A. (2007), "Skating on Thin Ice: Rule Changes and Team Strategies in the NHL", *Canadian Journal of Economics*, 40 (2), 493-514.
- Boyd, D. W. and Boyd, L. A. (1995), "Strategic Behaviour in Contests: Evidence from the 1992 Barcelona Olympic Games", *Applied Economics*, 27 (11), 1037-1043.
- Bradbury, J. C. and Drinen, D. (2006), "The Designated Hitter, Moral Hazard, and Hit Batters: New Evidence from Game-Level Data", *Journal of Sports Economics*, 7 (3), 319-329.
- Brocas, I. and Carrillo, J. D. (2004), "Do the "Three-Point Victory" and "Golden Goal" Rules Make Soccer More Exciting?", *Journal of Sports Economics*, 5 (2), 169-185.
- Carrillo, J. D. (2007), "Penalty Shoot-Outs: Before or after Extra-time?", *Journal of Sports Economics*, 8 (5), 505-518.
- Chiappori, P.-A., Levitt, S. and Groseclose, T. J. (2002), "Testing Mixed Strategy Equilibria When Players Are Heterogeneous: The Case of Penalty Kicks in Soccer", *American Economic Review*, 92 (4), 1138-1151.
- Clarke, S. R. and Norman, J. M. (1995), "Home Ground Advantage of Individual Clubs in English Soccer", *Journal of the Royal Statistical Society, Series D (The Statistician)*, 44 (4), 509-521.
- Dilger, A. and Geyer, H. (2009), "Are Three Points for a Win Really Better Than Two? A Comparison of German Soccer League and Cup Games", *Journal of Sports Economics*, 10 (3), 305-318.
- Easton, S. T. and Rockerbie, D. W. (2005), "Overtime! Rules and Incentives in the National Hockey League", *Journal of Sports Economics*, 6 (2), 178-202.
- Fédération Internationale de Football Association (2009), *Laws of the Game: 2009/2010*, available at: <http://www.fifa.com/mm/document/affederation/federation/81/42/36/lawsofthegameen.pdf>
- Goff, B. L., Shughart, W. F., II and Tollison, R. D. (1997), "Batter Up! Moral Hazard and the Effects of the Designated Hitter Rule on Hit Batsmen", *Economic Inquiry*, 35 (3), 555-561.
- Goff, B. L., Shughart, W. F., II and Tollison, R. D. (1998), "Moral Hazard and the Effects of the Designated Hitter Rule Revised", *Economic Inquiry*, 36 (4), 688-692.
- Guedes, J. C. and Machado, F. S. (2002), "Changing Rewards in Contests: Has the Three-Point Rule Brought More Offense to Soccer?", *Empirical Economics*, 27 (4), 607-630.
- Haugen, K. K. (2008), "Point Score Systems and Competitive Imbalance in Professional Soccer", *Journal of Sports Economics*, 8 (2), 191-210.
- Longley, N. and Sankaran, S. (2005), "The NHL's Overtime-Loss Rule: Empirically Analyzing the Unintended Effects", *Atlantic Economic Journal*, 33 (1), 137-138.
- Page, L. and Page, K. (2007) "The second leg home advantage: Evidence from European football cup competitions", *Journal of Sports Sciences*, 25 (14), 1547-1556.
- Palacios-Huerta, I. (2003), "Professionals Play Minimax", *Review of Economic Studies*, 70, 395-415.
- Pollard, R. (1986), "Home Advantage in Soccer: A Retrospective Analysis", *Journal of Sports Sciences*, 4 (3), 237-248.
- Ridder, G., Cramer, J. S. and Hopstaken, P. (1994), "Down to Ten: Estimating the Effect of a Red Card in Soccer", *Journal of the American Statistical Association*, 89 (427), 1124-1127.
- Rottenberg, S. (1956), "The Baseball Players' Labor Market", *Journal of Political Economy*, 64 (3), 242-258.
- Stefani, R. T. and Clarke, S. R. (1992), "Predictions and Home Advantage for Australian Rules Football", *Journal of Applied Statistics*, 19 (2), 251-261.
- Winchester, N. (2010), "Optimal Super Rugby Bonus Points Revisited", in: Lenten, L. J. A. (ed.), *Economics of Sports Leagues: An International Perspective*, Edward-Elgar, Northampton, forthcoming.

## 7 Appendix

### 7.1 Summary of Competitions

Table 8 summarizes the competitions (cups) in the used sub-sample of knockout stage playoffs, and the reported number of observations relates to series, not individual games within the series. The table lists competitions with more than five series (and contains 3743 games out of the 3815 we use).

TABLE 8: Summary of Competitions

Country	Competition	Existing data range	Number of series
AUT	ÖFB Stiegl Cup	2008-9	43
BEL	Beker van Belgie	2008-9	55
BUL	Bulgarian Cup	2008-9	38
CRO	HR Nogometni Cup	2008-9	37
CZE	Czech cup	1998-2009	265
DEN	Landspokal	2007-9	103
ENG	Carling Cup	2008-9	97
ENG	Championship	2004-2009	18
ENG	FA Cup	2007-9	269
ENG	LDV Trophy	2008-9	59
ESP	Copa del Rey	2007-9	108
FIN	Suomen Cup	2007-9	42
FRA	Coupe de France	2007-9	113
FRA	Coupe de la Ligue	2008-9	46
GER	DFB Pokal	2007-9	60
GER	Liga Pokal	2003-2007	20
INT	UEFA Champions League	1998-2009	130
INT	UEFA Champions League Qualification	1999-2009	208
INT	CONCACAF Champions League	2009	8
INT	Copa Libertadores	2009	7
INT	Copa Sudamericana	2008-9	62
INT	Cup Winner's Cup	1997-1999	9
INT	EURO	1996-2008	28
INT	Gold Cup	2009	7
INT	UEFA Cup	1997-2009	918
INT	UEFA Europa League	2009	134
INT	UEFA Super Cup	2003-9	6
INT	FIFA World Cup	1998-2006	48
INT	FIFA World Cup - Promotion - Europe	2005-9	7

GRE	Greek Cup	2008-9	35
IRL	FAI Cup	2008-9	39
ITA	Coppa Italia	2007-9	114
ITA	Serie B promotion/relegation	2005-9	17
MEX	Primera Division	2008-9	21
NED	Eredivisie	2006-9	31
NED	KNVB Beker	2007-9	108
NOR	NM Cupen	2008-9	39
POL	Puchar Polski	2008-9	31
POR	Taça de Portugal	2008-9	41
SCO	League Cup	2009	14
SCO	Scottish Cup	2008-9	60
SVK	Slovak Cup	2008-9	48
SWE	Svenska Cupen	2008-9	35
TUR	Türkiye Kupasi	2008-9	68
UKR	Ukrainian Cup	2008-9	43
USA	Major League Soccer	1999-2009	54

## 7.2 Summary of Match Outcomes

TABLE 9: Breakdown of Scores in the Extra-time Sub-sample

One-leg Series			Two-leg Series		
Regulation Score	Number of Deciders	Percentage of Games	Aggregate Series Score	Number of Deciders	Percentage of Games
0:0	151	43.0	0:0	17	26.6
1:1	133	37.9	1:1	8	12.5
2:2	55	15.7	2:2	27	42.2
3:3	10	2.8	3:3	8	12.5
4:4	2	0.6	4:4	3	4.7
			5:5	1	1.6

TABLE 10: Summary Statistics for the Extra-time Sub-sample

Competition	Number of extra-time matches	Proportion of Games with at Least One Goal					
		In Extra-time				In Regulation Time	
		Mean (both halves)	Standard Deviation (both halves)	Mean (first half)	Mean (second half)	Mean	Standard Deviation
Coupe de France	46	0.239	0.431	0.130	0.217	0.652	1.120
UEFA Cup	27	0.519	0.509	0.259	0.370	2.000	1.687
KNVB Beker	27	0.741	0.447	0.407	0.593	2.481	1.949
Coppa Italia	27	0.407	0.501	0.259	0.222	2.259	1.607
Carling Cup	24	0.667	0.482	0.458	0.375	1.917	1.613
DFB Pokal	21	0.619	0.498	0.429	0.524	1.714	1.454
Copa del Rey	20	0.500	0.513	0.350	0.350	1.100	1.210
Türkiye Kupası	18	0.444	0.511	0.278	0.278	1.444	1.338
FA Cup	16	0.750	0.447	0.188	0.688	1.750	1.483
FIFA World Cup	15	0.400	0.507	0.200	0.200	1.200	1.265
UEFA Champions League	15	0.600	0.507	0.200	0.533	1.467	1.598
Coupe de la Ligue	15	0.600	0.507	0.267	0.533	1.733	1.486
Taça de Portugal	14	0.214	0.426	0.071	0.214	1.143	1.512
EURO	14	0.571	0.514	0.214	0.357	0.857	1.027
Landspokal	14	0.643	0.497	0.500	0.357	1.571	1.950
<b>TOTAL</b> (including ALL available extra-times)	<b>440</b>	<b>0.527</b>	<b>0.500</b>	<b>0.300</b>	<b>0.391</b>	<b>1.566</b>	<b>1.614</b>

Note: the table only lists competitions with at least 14 extra-times. The correlation between the extra-time and regulation time values among these games is 0.577, which suggest that various competition/country specific factors are present. As apparent when comparing Tables 8 and 10, the proportion of games ending in extra-time differs substantially across competitions. The main factors that increase this proportion are: (i) a higher proportion of one-leg series (due to less time to resolve the series than in two-legs, and the absence of the away goal rule); (ii) more equally balanced teams; and (iii) lower scoring games.<sup>24</sup> The UEFA EURO is a good example of these characteristics, and the proportion of extra-times from 1996 has been a stunning 50%.

<sup>24</sup> There are additional idiosyncratic factors, such as the existence of replay matches in the FA Cup.

### 7.3 Estimated Marginal Effects of Section 4.2 for Selected Competitions

We depict two international tournaments (INTL=1), namely the FIFA World Cup, involving one-leg series (LEGS=0) played on neutral ground (NEUT=1); and the UEFA European Champions League - with two-leg series (LEG=1) and home and away games (NEUT=0). For both competitions we report the quarter-final stage (ROU=2, which is the mean of this variable), and two different UNBAL levels, namely: (i) exactly even teams (predicted winning probabilities of the teams from bookmakers' odds are 1/2 and 1/2); and (ii) a 2:1 favourite scenario (predicted winning probabilities of the teams are 2/3 and 1/3). In each case, we report the marginal effects relevant for different regulation time scores. Tables 11-12 do so for the specification in Section 4.2 with overall probability of scoring.

TABLE 11: FIFA World Cup

Regulation Time Score	Overall Probability of Extra-Time Scoring for Exactly even teams			Overall Probability of Extra-Time Scoring for the 2:1 Favourite Case		
	Treatment Group	Control Group	Marginal Effect (%)	Treatment Group	Control Group	Marginal Effect (%)
0:0	0.619	0.352	76.0	0.650	0.383	69.6
1:1	0.719	0.461	56.0	0.746	0.495	50.6
2:2	0.801	0.574	39.6	0.822	0.607	35.4
3:3	0.864	0.680	27.1	0.879	0.709	24.0
<b>Weighted Mean</b>	<b>0.692</b>	<b>0.438</b>	<b>60.8</b>	<b>0.719</b>	<b>0.471</b>	<b>55.3</b>

TABLE 12: UEFA Club Competitions

Aggregate Regulation Time Score	Overall Probability of Extra-Time Scoring for Exactly even teams			Overall Probability of Extra-Time Scoring for the 2:1 Favourite Case		
	Treatment Group	Control Group	Marginal Effect (%)	Treatment Group	Control Group	Marginal Effect (%)
0:0	0.622	0.355	75.4	0.653	0.386	69.1
1:1	0.674	0.408	65.0	0.703	0.442	59.2
2:2	0.721	0.464	55.5	0.748	0.498	50.2
3:3	0.765	0.521	46.8	0.789	0.555	42.1
4:4	0.803	0.577	39.2	0.824	0.610	35.1
5:5	0.837	0.631	32.5	0.855	0.663	29.0
<b>Weighted Mean</b>	<b>0.700</b>	<b>0.443</b>	<b>59.8</b>	<b>0.728</b>	<b>0.476</b>	<b>54.3</b>

### 7.4 Estimated Marginal Effects of Section 4.3 for Selected Competitions

This section performs an identical exercise to that of Section 7.3, except that the estimates come from the logit specification with individual team's probability of scoring, and are then multiplied by two to provide the overall probability of scoring.<sup>25</sup> The results are reported in Tables 13-14.

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<sup>25</sup> For this reason in very high scoring games the overall probability may add up to slightly more than 1, in which case we have normalized it to 1. The presence of such cases implies that the specification with individual scoring probabilities is likely to be a slight overestimate for high scoring games. Nevertheless, since this applies to both the control and treatment groups, the marginal effect will be largely unaffected or a slight underestimate.

TABLE 13: FIFA World Cup

Regulation Time Score	Overall Probability of Extra-Time Scoring for Exactly even teams			Overall Probability of Extra-Time Scoring for the 2:1 Favourite Case		
	Treatment Group	Control Group	Marginal Effect (%)	Treatment Group	Control Group	Marginal Effect (%)
0:0	0.595	0.374	59.0	0.757	0.497	52.2
1:1	0.718	0.467	53.8	0.893	0.609	46.5
2:2	0.852	0.575	48.2	1	0.734	36.2
3:3	0.991	0.696	42.4	1	0.869	15.1
<b>Weighted Mean</b>	<b>0.693</b>	<b>0.451</b>	<b>54.5</b>	<b>0.852</b>	<b>0.589</b>	<b>46.0</b>

TABLE 14: UEFA Club Competitions

Aggregate Regulation Time Score	Overall Probability of Extra-Time Scoring for Exactly even teams			Overall Probability of Extra-Time Scoring for the 2:1 Favourite Case		
	Treatment Group	Control Group	Marginal Effect (%)	Treatment Group	Control Group	Marginal Effect (%)
0:0	0.731	0.478	52.9	0.746	0.501	48.9
1:1	0.797	0.531	50.1	0.809	0.553	46.3
2:2	0.865	0.587	47.3	0.873	0.608	43.6
3:3	0.934	0.647	44.4	0.938	0.665	41.0
4:4	1	0.709	41.0	1	0.725	37.9
5:5	1	0.774	29.2	1	0.787	27.1
<b>Weighted Mean</b>	<b>0.838</b>	<b>0.567</b>	<b>48.2</b>	<b>0.847</b>	<b>0.588</b>	<b>44.5</b>