



Continuous Optimization

When sports rules go awry

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ABSTRACT

Wright (2014) recently presented a survey of sporting rules from an Operational Research (OR) perspective. He surveyed 21 sports, which consider the rules of sports and tournaments and whether changes have led to unintended consequences. The paper concludes: “Overall, it would seem that this is just a taster and there may be plenty more such studies to come”. In this paper we present one such study.

This is an interdisciplinary paper, which cuts across economics, sport and Operational Research. We recognize that the paper could have been published in any of these disciplines but for the sake of continuity with the paper that motivated this study, we wanted to publish this paper in an OR journal. We look at specific examples where the rules of sports have led to unforeseen and/or unwanted consequences. We hope that the paper will be especially useful to sports administrators, helping them to review what has not previously worked and also encouraging them to engage with the scientific community when considering making changes.

We believe that this is the first time that such a comprehensive review of sporting rules, which have led to unexpected consequences, has been published in the scientific literature.

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1. Introduction

Wright (2014) recently published an invited review which looks at sporting rules from the perspective of Operational Research (OR). He considered 21 sports, carrying out a post-hoc analysis of rule changes, finding, for example, that changes in the rules of volleyball did lead (as desired) to more predictable match lengths but also led to more defensive play, which was unforeseen. Other sports have also changed their scoring systems in a similar way. These include squash, ping pong, beach volleyball, badminton, lawn bowls and tennis (for example the mixed double's final set being played as a “Super-Tie Break”, sometimes referred to as a “best of two” format).

It might be assumed that rules for a given sport remain relatively static. This might be true for many sports, but for some sports rules change almost every year. The Australian Football League is one such example. Fig. 1¹, shows that in the first two decades following the formation of their Rules Committee in 1994, 51 rule changes were made, with only 2010 having no changes.

This compares to only 17 rule changes over the previous 20 years (1974–1993), with 12 years seeing no changes. We suspect that some changes were necessitated by unintended consequences of earlier rule changes. An example is the 2006 changes which allowed a player taking a kick-out from a behind to proceed without waiting for the goal umpire to finish waving his/her flags. We believe this caused the frequency of rushed behinds (exhibiting negative play) to increase over the following two years, culminating in Hawthorn's 11 rushed behinds in their 2008 Grand Final defeat of Geelong. This resulted in a rule change in 2009 preventing rushed behinds unless under immediate pressure from an opposition player. Other rule changes were also due to the fact that the Australian Football Council was disbanded and the AFL Rules Committee came into existence and started a series of rule changes to both clean up, and speed up, the game². We note that under the Australian Football Council governance structure, rule changes were harder to pass because it required a double-majority vote. There is nothing to suggest that the number of rule changes in the AFL will decrease³.

Wright (2014) suggested that further studies may be possible and this paper is one such study that considers specific examples from a number of sports to see where rules had unintended con-

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¹ <http://www.afl.com.au/afl-hq/the-afl-explained/rule-changes-1858-2013>.

² https://en.wikipedia.org/wiki/Laws_of_Australian_rules_football.

³ A safer and more exciting game, The Australian, sport section, 23 July 2015.

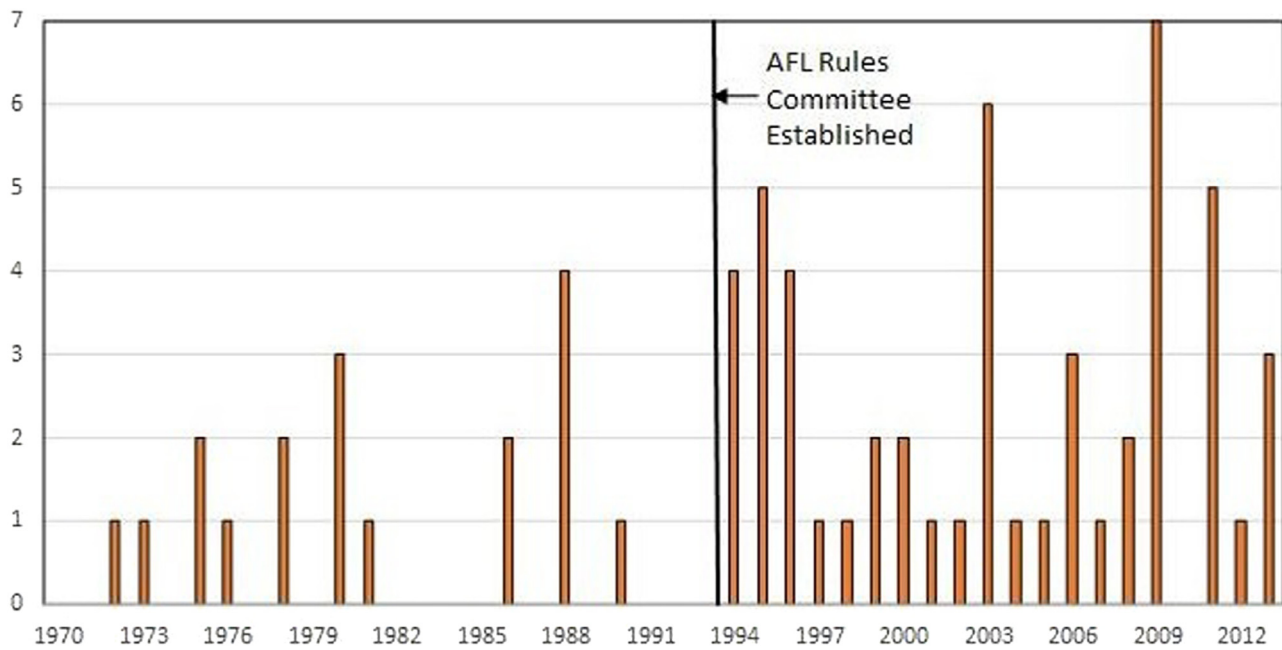


Fig. 1. Number of AFL rule changes, by year (1970–2013).

sequences, many of which are seen as controversial. Some of these are drawn from Wright (2014), but more detail is given than was possible in that paper. Others are drawn from our own knowledge and experience. We believe that our study is comprehensive but by no means exhaustive. We hope that this interdisciplinary paper (which cuts across economics, sport and OR) makes a contribution to all these areas but, more importantly, it will enable the community to further study games, incentives and strategies in what is a highly competitive environment. Furthermore, the pitfalls of sports rules provide useful analogies to policymakers, highlighting the importance of effective public policy design to improve societal and economic outcomes by circumventing perverse incentives and other suboptimal characteristics.

We also recognize that administrators have competing objectives (provide entertainment, ensure the sport is profitable, develop the sport etc.), whereas a single athlete's aim is typically to win. Athletes will also want to set records, feature in the record books, become recognized by the public, develop contracts with commercial companies etc., but all of these are dependent on them winning, even if this is to the detriment of other objectives, such as entertaining the crowd. Some athletes may want to play more attractively, but may also have the attitude that it is the administrators' responsibility to set the right incentives for them to do so, allowing them to satisfy this objective while seeking to simultaneously satisfy their own. This can raise tensions in areas such as *tanking* (the act of deliberately dropping points or losing a game in order to gain some other advantage) where it is seen as being against the spirit of the game but does meet the objective of the athlete, yet not the administrators. Examples of tanking are a feature of this paper, occurring in several sports.

We note that there are many references to URLs in this paper (all last accessed, April 2016). We recognize that it is not normal to include so many URLs in a peer reviewed scientific paper but much of what we report has not been reported in the scientific literature and we hope that the URLs provide additional material (such as videos of sporting plays, interviews, etc.) which are of interest to the reader.

1.1. Structure of the paper

We faced a decision as to how to structure the paper. Would it be best to structure the examples around particular sports (e.g. badminton, football, rugby etc.), or would it be better to structure it around sporting events (e.g. Olympics, World Cups etc.), even on some other basis? There is no perfect answer, but we have structured the paper alphabetically by sport (Section 3), as this is likely to be how the majority of readers would wish to access the paper. For example, sports administrators and fans who wish to focus on a particular sport. Where necessary, we have cross-referenced material to provide access to related material. In Section 4 we have provided examples (salary caps, player drafts and tournament formats), which cut across a number of sports for which we felt that it would not be sensible to split into specific sports.

2. Related work

This paper considers the unexpected consequences of when rules are either changed, or when existing rules lead to unforeseen events due to specific, and often unusual, circumstances. Lack of rules, for a given situation, could also be problematic. One of the reasons why rule changes can lead to situations in which the administrators and supporters would prefer not to happen is that it is difficult to trial changes in practice. Even if they could be tested, it is unlikely that all rogue cases would be revealed. However, it is not always the case that the effect of possible rule changes cannot be studied, at least statistically, to provide some level of confidence that a rule change would have. In this related work, we draw out some of the studies that have been reported in the scientific literature studying rule changes. We would also refer the reader to Wright (2014) for more examples.

Lenten and Winchester (2015) studied (competition) bonus points in Super Rugby. Some sports do not just attribute winning with being the primary consideration, but the margin of the win (or achieving a certain scoring outcome) may lead to bonus points. These rules are designed to motivate more attacking play, leading

to more excitement for the supporters. Lenten and Winchester refer to this as a secondary reward. They studied the last eight minutes to see if playing behavior changed. They concluded that it did, and in a way that was seen as favorable by the administrators. They further conclude that the Six Nations Championship and Australia's National Rugby League could also benefit from a similar bonus points system due to a decline in the number of tries in these competitions. The paper concluded by saying: "... the results show how the awarding of league points can, to a degree, be used to alter tactics in ways deemed favorable by administrators."

Penalty shootouts in football are seen by many as an unacceptable way to end a football match, leading to cautious play during extra time. Lenten, Libich, and Stehlík (2013) suggest that a shootout could alternatively be held *before* extra time, with the result determining the match winner only if the subsequent extra time fails to deliver a result. Their inference is that this would result in more attacking play during extra time. Of course, to see the results of these proposed changes would require empirical evidence by actually introducing the rule in a live (and probably more than one) competition, but their binary-response models using existing match data robustly estimate that the odds of scoring in extra time would increase three-fold, with the FIFA World Cup and the UEFA club competitions having a probable increase in scoring outcomes of 45–60 percent.

One of the challenges in generating a set of fixtures is to create a schedule that is seen to be fair both before and after the games are played. The OR literature has many examples that report how sports schedules can be generated (e.g. Bartsch, Drexler, & Kröger, 2006; Croce & Oliveri, 2006; Goossens & Spijksma, 2012; Kendall, 2008; Rasmussen, 2008; Wright, 2006). As a demonstration of the importance of the schedule to the underlying economics, Lenten (2015) considers the bias of the schedules for the 2002–2011 National Football League (NFL) seasons and modifies a recently introduced model (Lenten, 2011) to provide an assessment of how these (unbalanced) scheduling biases affect the competitive balance of such leagues. There are several surveys available (e.g. Kendall, Knust, Ribeiro, & Urrutia, 2010; Rasmussen & Trick, 2008; Ribeiro, 2012; Wright, 2009) on sports scheduling which, some would argue, is one of the most important aspects of designing fair sporting competitions.

3. Examples from specific sports

In this section, we provide many examples of when sports rules caused unexpected results. Many of these are well known to the relevant sporting community, but have not been recorded in the scientific literature. Due to this, we have had to provide links to news stories, or to videos, which highlights the example under discussion. We hope that by providing details here, this can be used as a future point of reference for the scientific community. We provide comments wherever we feel that we have something to add to the discussion.

3.1. Athletics: false starts

It is known that some swimmers and particularly runners (specifically sprinters) used to false start strategically as part of their game plan to psych-out their fellow competitors. While it used to build drama in some cases it has become almost ridiculous. While far from the worst case, the 1996 Olympic men's 100 meter final is worth watching⁴.

A brief description of how the IAAF rules have changed is as follows. From 2003, IAAF rules stated that after any false start

was committed, all athletes were to be warned. Any subsequent false start by any athlete(s) led to immediate disqualification of that athlete(s). Previously, disqualification only occurred after the same athlete false-started twice. In August 2009 the IAAF announced that from January 2010, a zero-tolerance stance to false starts would be adopted. Athletes false-starting are now immediately disqualified.

While the rule change has indeed worked as intended, it creates a double-edged sword. Specifically, the obvious downside is the possibility of high-profile disqualifications before the race is effectively run, of which there were quite a few in the 2011 World Championships in Daegu, none more so than Usain Bolt⁵.

Other Olympic examples can be seen in Sections 3.3.1, 3.8.1 and 3.9.8.

3.2. Australian football – AFL

As well as being a sport that has seen a lot of rule changes in recent years (see Section 1) the AFL has a best player award every year, the Brownlow Medal⁶, which dates back to 1924. The vote count has now become a huge television event.

It has a peculiarity that we are not aware exists elsewhere. It is not only a 'best' award, but also the 'fairest', insofar that any player who is reported for any on-field offense, for which that player is suspended (even for one match), then becomes ineligible to win it in that year (in 2005, the criteria were altered slightly to accommodate changes to the tribunal system). Among other reasons, this rule acts as a further incentive especially for star players to remain clean. The award is for most votes, with a 3–2–1 system in each match, given by the umpires who also report players for offenses.

In 1996, three players (for the first time) tied for the most number of votes. However, also for the first time, one of them (Corey McKernan) was ineligible. Therefore, only the other two shared the award. A news report⁷ is available. To add insult to injury, the reportable offense for which he was made ineligible was questionable at best. The following year (1997), history repeated itself. This time Chris Grant would have won the medal outright, as he had finished one vote ahead of winner Robert Harvey. This has not occurred since, yet the rule still persists.

Public perception is mixed on this. Some would take the view that it is a huge embarrassment if the vote-leader is ineligible, while others would claim it as evidence that the rule is doing exactly as intended – maintaining fair play.

3.3. Badminton

3.3.1. Women's doubles badminton at the 2012 Olympics

In the initial stages of the badminton competition in the 2012 Olympics, eight women players (both South Korea teams and one team each from China and Indonesia) were disqualified from the competition. The women were charged with "not using one's best efforts to win a match" and "conducting oneself in a manner that is clearly abusive or detrimental to the sport." They were found guilty of trying to throw matches in order to get (perceived) easier draws in the knockout stages of the competition.

To give one example of the circumstances that led to these disqualifications, Table 1 shows the state of the competition before the last Group A game. Russia and Canada had completed all their matches. Korea and China had won all their previous matches (i.e. they had both beaten Russia and Canada) so, in effect, they were playing for first and second place in the group. The first-placed team were to play the second-placed team from Group C in the

⁵ <https://www.youtube.com/watch?v=cgVJP0RmR-Y>.

⁶ http://en.wikipedia.org/wiki/Brownlow_Medal.

⁷ https://www.youtube.com/watch?v=Lkl_mkfCWok.

⁴ <https://www.youtube.com/watch?v=pqijESw6xHg>.

Table 1
Group A table of the badminton women's doubles at the 2012 Olympics.

	Played	Won	Lost	Sets won	Sets lost	Points
Korea	2	2	0	4	0	2
China	2	2	0	4	0	2
Russia	3	1	2	2	4	1
Canada	3	0	3	0	6	0

quarter-finals, where the second-placed team would play the top-placed team from Group C.

However, it is believed that China and Korea were looking further ahead in the draw. Due to the timing of the games, the final positions of Group D were already known before the last Group A game started. Another China team (referred to as C_2) were placed second in Group D. This meant that they were in the top half of the draw, going into the quarter finals. The second-placed teams in Group A would be in the bottom half of the draw and could not face C_2 until the final. Once this tactic became apparent, Korea (another Korean team) also tried to lose their final game in Group C (against Indonesia) to subvert the plan, resulting in four teams being disqualified.

Comments: We assume that the tournament structure was established so that there is an incentive to top your group so that you earn an easier match in the quarter-finals as you would be playing a second-placed team. The teams in question were obviously looking further ahead than just the quarter-finals. There might be some merit in timing the final-group matches at the same time, as is done in other tournaments, although in this case it would not have had any effect as the bottom-two teams (in both Groups A and C) were already eliminated as the top two teams had already beaten both those teams.

An alternative is to draw the quarter-finals only after all the group matches have taken place (as in the UEFA Champions League). There could be some seeding to stop the top teams being drawn against each other although, in our view, this might not be a bad thing as a 'fair' draw would stop teams speculating how the knockout stages would play out and play the group matches accordingly.

This badminton match is an example of *tanking*; the act of deliberately dropping points or losing a game in order to gain an advantage. It is generally felt to be against the spirit of the game. Tanking in other sports is discussed in Sections 3.6, 3.11.2, 3.12.2 and 4.1 (Point 1). Other Olympic examples can be seen in Sections 3.1, 3.8.1 and 3.9.8.

3.4. Baseball

3.4.1. Forcing a walk

In baseball, if four balls have been pitched outside of the strike zone (meaning that it is difficult, or impossible for the batter to hit), the player on strike gets a free walk to first base. However, there are incidents in which the fielding team would like a player to walk, so the pitcher intentionally pitches outside of the strike zone. We assume that forcing an unintentional walk was not an intended consequence when the rules were drawn up, although it seems to be an accepted part of the game now.

However, exploiting this rule can sometimes go wrong. There are examples⁸ where a pitcher was attempting to force batter to walk, but the batter managed to hit the ball, leading to a run being scored.

3.4.2. Designated-hitter rule

The 'designated-hitter' rule in Major League Baseball (MLB) is a favorite rule oddity of research in economics, specifically as a way of testing moral hazard effects arising from its implementation. MLB rule 6.10 states that a designated hitter "... may be designated to bat for the starting pitcher and all subsequent pitchers in any game". The rule was introduced in MLB's American League (AL) in 1973, to tilt the balance of power in the game back towards batters, during an era in which pitchers had been more dominant for quite some time. Meanwhile, MLB's other half – the National League (NL) – has never implemented the rule. The rule has been effective in its primary intention – the AL has since posted consistently higher batting averages than the NL. However, (among its various other unintended consequences) because under this rule pitchers do not have to bat themselves, there may exist a moral hazard by which they are more likely to hit opposition batters on the body while pitching, as there is effectively no chance of reprisal by an opposition pitcher gaining revenge for their teammate(s).

The rule is attractive to economists because the AL and NL provide a very rare example in the sports industry of two leagues that are highly comparable in all aspects – other than this rule. Thus, the rule itself provides an unusually natural experimental framework in which incentives induced by a playing rule can be tested robustly. Significant contributions in the sports economics literature here have been provided by Goff, Shughart II, and Tollison (1997), Goff, Shughart II, and Tollison (1998), Bradbury and Drinen (2006), who all show that the rule produces a higher rate of hit batters in the AL. The evidence is particularly clean prior to 1997, when AL and NL teams never played each other during the regular season. Since the introduction of this 'interleague play', however, the comparison is less clear, as interleague matches invariably involve one team playing under designated hitter conditions that they are not normally accustomed to.

3.5. Basketball

The three-point shot, a shot from behind a designated line (a shot on or inside the line scores only two points) potentially enables teams to score a lot of points quickly, particularly towards the end of the game when the points gap could be large. The rule became popular after the now-defunct American Basketball Association introduced it in the 1967–68 season, although it was used before this.

Ray Stefani, in a blog post for the New York Times⁹ has studied the effect of this rule, showing that it is not always best to adopt a strategy to go for three-points. For example, he notes that the team who shot the lower percentage of three-pointers from beyond the three-point line won 32 out of 48 games (in the N.C.A.A. men's basketball tournament) and won seven out of eight games (round-of-16 matchups and all four regional finals).

Although it might look like a good idea to try and score three-point shots, Stefani concludes: "Looking only at percent 3s, Kentucky would beat Kansas in the final. Memo to coaches: stick to about a quarter of threes: total shots, free throws, rebounds and total points will all take care of themselves", concluding that teams overuse the three-point option and they should limit these attempts to about 25 percent of the time.

Comments: This rule change has not led to any dramatic consequences but is an example of teams not recognizing how to adapt to the change. It appears that they are drawn to the incentive of larger point gains, but do not realize the dangers of doing this.

⁸ <https://www.youtube.com/watch?v=a6YzVvtXoaY>.

⁹ http://thequad.blogs.nytimes.com/2012/03/29/best-use-of-the-3-in-moderation/?_r=0.

That is, the disadvantages can easily outweigh the advantages due to an over expectation of the abilities of the players to score from the 3-point zone.

3.6. Tanking in basketball

In the 2014 FIBA basketball World Cup Australia rested their key players in their final group match at the end of the game against Angola. This enabled Angola to win 91–83, noting Australia were leading by 42–29 at half time. The suspicion of tanking was leveled at Australia as losing that game meant they finished in third place which delayed meeting the United States until the semi-finals, rather than the quarter-finals. In fact, Australia unexpectedly lost by one point (65–64) to Turkey in the next round. Australia were later investigated, and subsequently cleared, of tanking. Tanking in other sports is discussed in Sections 3.3.1, 3.11.2, 3.12.2 and 4.1 (Point 1). There is more discussion on basketball in Section 4.1, item 1.

3.7. Cricket

3.7.1. Duckworth/Lewis method

The Duckworth/Lewis (D/L) method (Duckworth & Lewis, 1998) system in cricket is undoubtedly one of the successful rule changes that has improved the game. The system is used to determine the winner of a rain-affected match. The model takes into account the number of wickets remaining and the number of balls left to bowl. These are used to set a revised target for the team that is batting, which has a lesser number of balls than their opponents.

Prior to the D/L system being adopted, other systems had been used that adjusted the total for a rain-affected match. A match that highlighted the problems with the ‘run-rate’ method was between Australia and the West Indies in the World Series, played on 18 January 1989 in Sydney. The rules gifted the match to the side batting second. We can do no better than quote an (edited) match report¹⁰.

“West Indies won by eight wickets being set a revised target of 108 in eighteen overs. The World Series Cup of 1988–89 could hardly have had a less satisfactory ending. The toss virtually decided it, not because the pitch, now being used for the third time in seven days, cracked up, but as a result of the regulations, which, in the event of much rain, are too heavily loaded in favor of the side batting second.

There were two stoppages, the first of two hours during Australia’s innings, the second of 85 minutes soon after West Indies had set out to make 227 to win at 5.97 runs an over.

When the players went off for the first time Australia were 83 for two. Left with only another 14.5 overs’ batting after the resumption – it had by then become a 38-overs match – they scored a further 143 runs. When the West Indian innings was interrupted they were 47 for two after only 6.4 overs. With the rain relenting soon after nine o’clock, just in time for the match not to be abandoned and another started next day, West Indies found their requirement reduced from 180 in 31.2 overs to 61 from 11.2 overs. Most sides would have expected to achieve that. In the post-mortem Australia’s captain called for the regulations to be revised; Richards was happy with them as they were.”

As a counter example, a match between England and South Africa, again in Sydney, on 22 March 1992 in the World Cup semi-final made it impossible for the team batting second to win by virtue of the most productive overs rule. Again, we quote from the (edited) match report¹¹.

“This game’s closing minutes buried South Africa’s World Cup hopes, and whatever credibility the rain rule had retained. By putting

pressure on the team batting second, the rule supposedly created exciting finishes; on this occasion 12 minutes’ heavy rain, when South Africa needed 22 from 13 balls, adjusted their target first to 22 from seven, and then to 21 from one. McMillan could only take a single off Lewis. The losers were disconsolate, the winners embarrassed, and the crowd furious. Why, they asked, were the two overs not played out under the floodlights?

The majority blamed the World Cup’s organizing committee, and the inflexibility which prevented a second-day resumption. (The next day was set aside only for a completely new match, to be played if the second team had not faced 25 overs.) Justice was probably done; Wessels chose to field, knowing the rules and the forecast, and his bowlers were fined for going slow and depriving England of five overs’ acceleration. But it was not seen to be done, and fine performances on both sides were overshadowed by indignation.”

The D/L method has now been adopted worldwide and has helped to decide many rain-affected matches, with most observers believing that it is an improved, and fair method. However, there have been examples of where the D/L method has not had the intended consequence. In 2009 (4 June), in an English domestic T20 match between Sussex and Kent¹², at the end of their innings, Sussex had scored 131 for the loss of three wickets, in the allotted 20 overs. In the 11th over Kent fell behind the required run rate for only the second time. It was at this point that Sussex’s captain called up a fast bowler. A report of the game suggests that the captain knew what he was doing – *“With his team’s noses in front, Yardy called up Robin Martin-Jenkins to bowl from the gloomy Cromwell Road End.”*¹² The umpires consulted and decided that due to fading light (the umpires had been informed that the floodlights would not be available), and the change to a fast bowler, it would pose a danger to the batsman, the teams would have to leave the pitch. Using the D/L method, this meant that Sussex won by two runs, with nine overs still remaining.

In the 2003 (3 March) World Cup, South Africa’s captain, Shaun Pollock, admitted miscalculating in the final group-stage match with Sri Lanka¹³. Sri Lanka had scored 268, requiring South Africa to score 269 to win, and they needed to win to progress. However, a rain storm was likely and South Africa knew that the D/L method might come into play, so they had to ensure that they kept up with the D/L calculated total. As the rain started, the South African’s reached 229 (by virtue of a six), which was now level with the revised total. Some of the South African team, and supporters, celebrated and the final ball was simply guided around the wicket, thinking that it was of no consequence. In fact, South Africa needed one more run as the 229 resulted in a drawn match. The points were shared, resulting in South Africa’s exit from the competition.

Comments: Although there have been a couple of examples where D/L has caused some problems, it is generally accepted as being a fair system and resolves the problem of rain-interrupted matches. The fact that it has been in use since 1997 is testament to its robustness. Research still continues into the method (e.g. Duckworth & Lewis, 2004; Shah, Sampat, Savla, & Bhowmick, 2015; Stern, 2009) demonstrating that it is subject to refinement. We would suggest that the D/L method provides an excellent example of how the sporting community, and the scientific community, are able to collaborate in a way that meets the needs of both parties.

The Duckworth/Lewis method is often cited as a (if not the) leading example of OR making an impact in the real world. Dr Anthony Lewis returned the D/L method in the UK’s 2014 REF (Research Excellence Framework) as one of Oxford Brookes Univer-

¹⁰ <http://www.espn.com/cricket/story/150754.html>.

¹¹ <http://www.espn.com/cricket/story/150902.html>.

¹² <http://www.ecb.co.uk/news/domestic/sussex-v-kent,305816,EN.html>.

¹³ http://news.bbc.co.uk/sport3/cwc2003/hi/newsid_2810000/newsid_2816700/2816793.stm.

Table 2

Group B table of the 1999 cricket World Cup before the Australia/West Indies match.

	Played	Won	Lost	NRR	Pts
Pakistan	4	4	0	0.97	8
West Indies	4	3	1	0.88	6
Australia	4	2	2	0.77	4
New Zealand	4	2	2	0.00	4
Bangladesh	4	1	3	-1.01	2
Scotland	4	0	4	-1.61	0

Table 3

Group B table of the 1999 cricket World Cup after the Australia/West Indies match.

	Played	Won	Lost	NRR	Pts
Pakistan	4	4	0	0.97	8
Australia	5	3	2	0.73	6
West Indies	5	3	2	0.50	6
New Zealand	4	2	2	0.00	4
Bangladesh	4	1	3	-1.01	2
Scotland	4	0	4	-1.61	0

sity's impact case studies¹⁴ to highlight the impact that its research is making.

We would hope that there could be more of this type of collaborative activity in the future as both parties (academics and sports administrators) could benefit mutually from working together.

Finally, we note that the Duckworth/Lewis method is now known more formally as the Duckworth/Lewis/Stern method after Stern software revised the algorithm¹⁵. We have used the more familiar Duckworth/Lewis name in this paper as, at the time of writing, this is how it is more familiarly known and we did not want to introduce confusion.

3.7.2. 30 May 1999 – Australia vs West Indies World Cup 1999

The 1999 cricket World Cup was hosted in England, with some games being played in Scotland, Ireland, Wales and the Netherlands.

The twelve participating teams were split into two groups (Group A and Group B) of six teams. Within these groups each team played every other team, so each group comprised 15 games ($n(n-1)/2$, where $n=6$) The top three from each group progressed to the second round (called the 'Super Six') stage. In this stage, each team from Group A, played each team from Group B. The teams carried forward their points from the initial group stages against the teams who progressed from the same group. The top four teams from the Super Sixes contested the semi-finals.

In the 1999 World Cup, a group match between Australia and West Indies should have been an easy win for Australia, when the West Indies only scored 110 runs in 46.4 overs (it was a fifty-over match). This was an easy target for Australia but it took them 40.4 overs to reach the required 111 runs (for 4-wickets), with the final 24 runs taking Stephen Waugh and Michael Bevan 14.4 overs. To understand why it took Australia so long to reach this target, we need to delve a little deeper.

Table 2 shows the league table before the Australia/West Indies match and Table 3 shows the Group B table after the match.

The telling statistic is the secondary criterion used in this tournament to separate teams tied on points – the Net Run Rate (NRR). The net run rate is a measure that compares the number of runs scored against all your opponents, compared to the runs that your

Table 4

Australia's rolling 5-over run rate from overs 25–34.

Over	Score	Run rate – last 5 overs
25	83/4	4.20
26	87/4	3.80
27	90/4	3.40
28	92/4	3.60
29	92/4	3.00
30	92/4	1.80
31	92/4	1.00
32	98/4	1.60
33	99/4	1.40
34	101/4	1.80

opponents have scored against you. It also takes into account the number of overs. If the team is all out, then the full 50 overs is used, but if you are chasing a total and achieve the required total in (say) 40 overs, then that figure is used. A full description can be seen at the CricInfo web site¹⁶.

You will note that after the match, Australia's NRR had dropped from 0.77 to 0.73. West Indies NRR had dropped from 0.88 to 0.50.

Table 4 shows Australia's rolling five-over run rate between overs 25 and 34. It is apparent that Australia's scoring is slowing down. If Australia had continued to score at around four an over, the match would have completed at around over 32. This would have given Australia a NRR = 0.94 and West Indies a NRR = 0.38¹⁷.

So, what motivated Australia to go slow? Earlier in the tournament, New Zealand had beaten Australia¹⁸. It was in Australia's interest and, by extension, also in the interest of the West Indies, to try and get West Indies to qualify over New Zealand. If it came down to points, the NRR could be the deciding factor so it was in both teams' interest to keep the West Indies NRR as high as possible. There is no proof of cooperation between the two captains, but it was in both their interests to prolong Australia's innings, which was ultimately down to the way that the tournament had been designed. A further example of tacit collusion, or emerging cooperation?

The plan (if there was one) did not work out entirely. New Zealand, playing the next day, hence knowing the equation, bowled out Scotland cheaply and mowed down the target just quickly enough (17.5 overs) to sneak into third place marginally ahead of the West Indies, anyway. Rather than the 40.4 overs it actually took, Australia, had they gone a few more overs closer to the 47.2 they needed as a maximum to finish ahead of West Indies, could have made it even more difficult for New Zealand. Australia consequently had to win their next five games in succession (although they actually drew their semi-final against South Africa, proceeding on a better super six placing), rather than having the comfort of (all other things being equal), being able to lose one of their following three games in the second-round, and still go through to the semi-finals.

Australia went on to win the World Cup.

3.7.3. Australia vs New Zealand – World Series Cup – 01 February 1981

In a game between Australia and New Zealand, where the series had already been subject to a number of controversies, in the final game New Zealand needed six runs off the last ball to draw the game. The Australian captain (Greg Chappell) instructed the bowler, Trevor Chappell (his younger brother) to bowl underarm,

¹⁶ <http://www.espnricinfo.com/ci/content/page/429305.html>.

¹⁷ <http://www.theguardian.com/sport/1999/may/31/cricketworldcup1999.cricketworldcup5>.

¹⁸ <http://www.espnricinfo.com/ci/engine/match/65202.html>.

¹⁴ <http://results.ref.ac.uk/Submissions/Impact/117>.

¹⁵ <http://www.cricbuzz.com/cricket-series/cricket-news/69983/introducing-duckworth-lewis-stern-method>.

along the ground, so that the batsman could not score a six from the ball.

This was within the rules at the time but was considered to be against the spirit of the game. One of the commentators (Ian Chappell, former Australian captain and elder brother of the two Chappells on the field) was heard to say “No, Greg, no, you can’t do that”. In the Youtube video¹⁹ (see around 4 minutes, 55 seconds) Australian wicket-keeper Rodney Marsh is seen shaking his head and saying “No, mate”. Richie Benaud, also a former Australian captain and commenting on The Nine Network described the incident as “disgraceful”, saying it was one of the worst things he had seen on a cricket field and called for an immediate rule change (see around 5 minutes, 55 seconds to 8 minutes, 23 seconds)¹⁹, explaining that underarm deliveries had been disallowed in the official Test rules but this particular tournament (World Series Cup) had its own rules. Both country’s Prime Ministers were critical of the decision.

As a direct result of this incident, the International Cricket Council banned underarm bowling in limited overs cricket as “being against the spirit of the game”.

3.7.4. Incidents

In this section, we list a number of incidents, which have occurred in cricket, often resulting in rule changes.

1. Mike Brearley, the England captain in the 1979–80 (non-Ashes) Test series against Australia, objected to the use of an aluminum bat by Dennis Lillee, rather than one made of the more traditional willow, when he came out to bat in the Perth test. The basis of the complaint was that it was damaging the ball, even though the bat had been used in a previous Test in Brisbane against Sri Lanka with no complaints from the opposing team²⁰.

The umpires consulted with each other, but the matter was resolved by the Australian captain who sent for a willow bat for Lillee to use.

These days, the rules are well covered.

2. In a limited-overs match between England and the West Indies in Sydney, in 1979, Brearley again caused controversy by ordering all his fielders, including the wicketkeeper, to the boundary. Three runs were required off the last ball and by doing this he believed that it would be much more difficult to get the required number of runs. This was legal at the time but we believe that this led to introduction of the inner circle and fielding restrictions. The rules have changed over the years, but they are designed to encourage the batter to play shots, and try to hit fours and sixes.

3. In a limited-overs (55) match that took place on 24 May 1979 between Worcester and Somerset, Brian Rose, the captain of Somerset, knew that Somerset would qualify for the quarter-finals of the tournament as long as they did not lose by a heavy margin.

To achieve this, he declared after the first over, with the score at 1 run for 0 wickets (the over was actually a maiden, with the one run coming from a no-ball). Worcestershire took just ten balls to score the two runs required and the match was over in just 18 minutes, which included a ten-minute break between innings. Some spectators had not even taken their seats and many had traveled a long way to see eight minutes of cricket. What Rose had done was within the laws of the game (he had checked with the Test & County Cricket Board beforehand), but it was certainly outside the spirit of the game. Ironically,

if Somerset had lost the game they still would have qualified for the quarter-finals as Glamorgan’s game against Minor Counties was washed out and they did not achieve the victory they needed.

Eight days later, the Test & County Cricket Board called an emergency meeting of its disciplinary committee. They voted to expel Somerset from the competition (17 to 1). Even Somerset supported the motion (Derbyshire opposed it). The TCCB said that Rose’s action was “against the spirit of the game” and that it had “brought the game into disrepute”.

Comments: Even though the Test & County Cricket Board actions could be seen as being morally right, there is an argument that Somerset were punished for not breaching any rules. This is a rare scenario where no rules were broken, yet sanctions were imposed anyway under the banner of ‘bringing the game into disrepute’.

4. A similar incident to the one above occurred during the 1991/92 Sheffield Shield (Australia’s domestic long-form cricket competition) season (12–15 December 1991). Favorites New South Wales (NSW) had started the season slowly and needed a few outright wins. Playing Tasmania at the Sydney cricket ground was a perfect opportunity to get the full six points. However, torrential storms on the first two days meant that only a few overs had been bowled in Tasmania’s first innings. On a rain-affected swinging pitch, NSW bowled out Tasmanian cheaply (144), when play resumed on day 3. Despite first-innings points looking almost certain, captain Geoff Lawson opted to declare the NSW first innings at 0/0. He was relying on being able to bowl out Tasmania cheaply for a second time, and then chase down a modest target. The scorecard²¹ shows that it almost worked. At 132/2, chasing 261, the probability of them winning was high, but a late collapse saw them fall 48 runs short.

5. For many years, teams had used a tactic of bowling down the leg side and packing that side of the field in the hope that the batsman, in trying to steer the ball through these fielders would nick the ball and be caught out. It was not popular, but widely practised and was also known by the term *leg theory*.

In the 1932–33 Australia vs England series, England took this to new levels, mainly in an attempt to try and control Donald Bradman. They bowled at the body, not just to restrict, but also to intimidate. This ultimately led to a change in the rules so that only two fielders are allowed behind square on the leg side, thus making body lining impractical.

Many years later, during 1970’s–1980’s, bouncers were used to intimidate the batsman. In 1991, the International Cricket Council (ICC) introduced a ‘one bouncer per batsman per over’ rule in an attempt to discourage this use of intimidation.

The ruling was not well received by players or umpires. English umpire Dickie Bird commented that it was farcical, believing that the decision of whether actions were intimidating should be left to the umpires. The rule was changed to two bouncers per over in 1994, with a two-run no-ball penalty if the bowler exceeded two bouncers an over. The ICC reverted to one bouncer per over in 2001, with a one-run no-ball penalty.

6. In a rain-affected match, the 2007 World Cup Final between Australia and Sri Lanka was reduced to 38 overs each. Further rain reduced Sri Lanka to 36 overs, who were chasing a total of 281, which was reduced to 269 under the Duckworth–Lewis method. After the 33rd over, the umpires called the players off due to bad light. The Australian team celebrated as they (correctly) believed that they had won but the umpires said that the final three overs had to be played as the match was

¹⁹ <https://www.youtube.com/watch?v=d2qpj-yBkwY>.

²⁰ <http://www.cricketcountry.com/articles/the-ashes-1979-dennis-lillee-walks-out-to-bat-with-an-aluminium-bat-20910>.

²¹ <http://www.espnricinfo.com/ci/engine/match/357662.html>.

suspended due to bad light and not rain. They said that these overs would be played the next day. Sri Lanka agreed to play the final three overs that evening as they required 61 runs from 18 balls, which was improbable. The last three overs were played in almost complete darkness (as the ground did not have floodlights), with Australia agreeing to only play spin bowlers. Australia won by 53 runs under the Duckworth–Lewis method. The umpires later apologized for the error.

7. In the 2007 World Cup, India unexpectedly lost their first match to Bangladesh and found themselves eliminated after only nine days, with the tournament then running for a further five weeks without them. Ratings and ICC revenue fell to well below expectations due to hundreds of millions of Indian televisions being switched off almost simultaneously. It might not be a surprise that the tournament format for the following World Cup in 2011 reverted to an earlier (1996 World Cup) format with two groups and a knockout-stage from the quarter-finals. This ensured India would remain in the tournament for as long as possible. This is an example of when one team is such a draw that they are *needed* in the tournament for as long as possible.
8. Test cricket is an oddity in that test series between some countries sometimes have a bilateral trophy on offer. The Ashes between England and Australia is good example. Not only is the test series at stake but the *winners* (importantly) also get to keep an 11 centimeter-high trophy. If the test series is a draw, the urn is kept by the country that currently holds it. This fact could influence the way that series are played, and almost certainly would in the case of the Ashes, as winning the series is far less important to the holders than not losing (drawing) the series. Let us take a theoretical example. Assume an Ashes test series is poised at 2–2, and England are the current holders. A final draw is good enough for England to retain the Ashes, but not good enough for Australia to win them. It is easy to see how the Australian captain would be willing to take chances to give his team every possible chance of winning the decider. If there were no Ashes to play for, and it is purely a test series, the captain might become more defensive, being happy with a draw, rather than risking a loss.

3.8. Cycling

3.8.1. Men's cycling team sprint at the 2012 Olympics

In an interview (2 August 2012), after the men's cycling team sprint, Great Britain's Philip Hindes said that he had deliberately crashed in an earlier round as he had not liked his start, so he wanted to have a restart. He was quoted as saying "*We were saying if we have a bad start we need to crash to get a restart. I just crashed, I did it on purpose to get a restart, just to have the fastest ride. I did it. So it was all planned, really.*"²² The British later claimed that it was misunderstanding as English is not Hindes' first language.

In the team sprints, restarts are allowed if a rider falls or has a mechanical fault. The judges ordered a restart, unaware at that time of the comments that would be made later. The team in second place accepted that the result would stand but suggested that the rules need to change.²³

Comments: It would appear strange that a cyclist falling means that a restart would take place and leaves the sport open to participants simply *falling off* until they get the start they desire. If this happened in another sport then the race would not be restarted.

²² <http://www.telegraph.co.uk/sport/olympics/cycling/9448399/London-2012-Olympics-Philip-Hindes-crash-sets-up-dash-to-Sir-Chris-Hoys-greatest-victory.html>.

²³ <http://www.reuters.com/article/2012/08/03/us-oly-cycl-ctmspr-day7-rules-idUSBRE8720RM20120803>.

Table 5

Group 2 table of the 1982 FIFA World Cup before the final match between Austria and West Germany.

Team	Pld	W	D	L	GF	GA	GD	Pts
Austria	2	2	0	0	3	0	+3	4
Algeria	3	2	0	1	5	5	0	4
West Germany	2	1	0	1	5	3	+2	2
Chile	3	0	0	3	3	8	-5	0

For example, in F1 motor racing, if a car has a mechanical problem there is no provision to restart the race. It would appear that the regulation governing team sprints would benefit from being reviewed.

Other Olympic examples can be seen in Sections 3.1, 3.3.1 and 3.9.8.

3.9. Football

In this section we take the meaning of *football* to be the European meaning, rather than the US meaning. The Australian version of the game (AFL) can be seen in Section 3.2. The USA version of the game (NFL) can be seen in Section 3.13.

3.9.1. 25 June 1982 – Austria vs West Germany, El Molinón stadium, Gijón, Spain

This match was the final game of the first-round stage (Group 2) of the 1982 FIFA World Cup. The other teams in the group, Algeria and Chile, had played each other the previous day. Before the game between Austria and West Germany, the group table stood as shown in Table 5.

A win by West Germany would place three teams on four points (a win was worth two points). If teams were level on points the first tie-breaker was goal difference. If Germany won by one (two resp.) goal(s), their goal difference would be +3 (+4 resp.), but Austria would drop to +2 (+1 resp.). This would mean that Austria and West Germany would both progress to the next stage. If Germany won by more than two goals then Austria would have the same goal difference (or worse) than Algeria which would put Algeria through.

After ten minutes West Germany scored. This removed any incentive for either team to score any more goals. Why should Germany attack in order to try and score a second goal, risking Austria scoring a goal on the break? Why should Austria attack, risking further goals being scored against it, which would risk its goal difference being further eroded?

The result was a boring game for the remaining 80 minutes, with no team really making an effort to score, often passing between their own players in their own half.

The Algerian fans were naturally upset, but so were some of the Austrian and West German fans who wanted to see a competitive match. There were reports of a West German fan at the game burning his own flag in the stands and many of the local Spanish fans were waving their handkerchiefs in an apparent display of disgust. The local newspaper, apparently, reported the match result in the crime section.

It was this match that led to a rule change that the final pair of group matches in the FIFA World Cup would thereafter be played simultaneously and, as far as we are aware, this has (mostly) resolved this issue.

This match, which has since come to be known as the 'Shame of Gijón', is an example of *tacit collusion* (Anderson, Freeborn, & Hulbert, 2015; Choe & Matsushima, 2013; Fonseca & Normann, 2012), which has some similarities with evolving cooperation in the Iterated Prisoner's Dilemma (Axelrod, 1984; Li, Hingston, & Kendall, 2011; Li & Kendall, 2014), which has been an active field

Table 6

Group C table of UEFA Euro 2004 before the final matches in that group.

Team	Pld	W	D	L	GF	GA	GD	Pts
Sweden	2	1	1	0	6	1	+5	4
Denmark	2	1	1	0	2	0	+2	4
Italy	2	0	2	0	1	1	0	2
Bulgaria	2	0	0	2	0	7	-7	0

Table 7

Group C table of the UEFA Euro 2004: final standings.

Team	Pld	W	D	L	GF	GA	GD	Pts
Sweden	3	1	2	0	8	3	+5	5
Denmark	3	1	2	0	4	2	+2	5
Italy	3	1	2	0	3	2	+1	5
Bulgaria	3	0	0	3	1	9	-8	0

of research for over 30 years, and has strong links with the pioneering work of Nash (1950, 1951) in Game Theory.

3.9.2. 31 August 1998 – Thailand vs Indonesia, 1998 AFF championship

In the group stages, both Thailand and Indonesia were already certain of reaching the semi-finals. The winner of the group would have to play the hosts Vietnam. The second-placed team would play Singapore. The match against Singapore was seen as the better option, so there was an incentive to lose. The score was 2–2 after 90 minutes and in extra time Mursyid Effendi deliberately scored an own goal for Indonesia, giving Thailand a 3–2 victory²⁴. FIFA fined both teams 40,000 USD for: “violating the spirit of the game”. Effendi was banned for a year from the domestic game and for life from international duties.

3.9.3. 22 June 2004 – Denmark vs Sweden, Porto, Portugal

Just before the final group matches, in Group C of the 2004 UEFA Euro championship, the group table is shown in Table 6. The top two would go through to the knock-out stages.

The most striking element is that both Sweden and Denmark beat Bulgaria and they also drew against Italy. Whatever happened Bulgaria would be eliminated. Even if they had beaten Italy, they would only be on three points and Sweden and Denmark would go through. If Italy vs Bulgaria was a draw then neither would have gone through as Italy would only be on three points – not enough to catch Sweden and Denmark.

The only result that could have affected who went through was if Italy had won (giving them five points). It was natural to assume that this would happen as Italy were considered a stronger team and had already drawn with Sweden and Denmark, both of which had beaten Bulgaria. And, indeed, this is what happened, Italy beat Bulgaria 2–1.

Analyzing the situation from the position of Sweden and Denmark, let us assume that Italy would win, as any other result means that both Sweden and Denmark progress. If either Sweden or Denmark had won the match between the two teams then the loser would be eliminated as Italy would be on five points, as would Sweden (resp. Denmark) with Denmark (resp. Sweden) being on four points.

The more interesting scenario is if Sweden and Denmark draw. The three teams will be on five points. If we assume that they drew, with a scoreline of 2–2 (in fact, this was the outcome), the final standings would be as shown in Table 7.

As three teams are on five points, there is a series of tie-break conditions²⁵:

1. Greater number of points in the matches between the teams in question.
As the three teams have all drawn with each other, the number of points will be equal, so this tie-breaker does not separate them.
2. Goal difference from matches between the teams in question.
Again, as the teams had all drawn against each other, the goal difference will not separate them.
3. Greater number of goals scored in matches between the teams in question.
The results of the three teams were Denmark 0–0 Italy; Italy 1–1 Sweden; Denmark 2–2 Sweden. Sweden had scored 3 goals, Denmark 2 and Italy 1. Under this tie-break condition Italy were eliminated. It would have been interesting if Denmark and Sweden had drawn 1–1. Then the goal totals would have been Sweden 2, Denmark 1 and Italy 1 which would have meant that Denmark and Italy would have had to be further separated. A 0–0 scoreline would have seen Italy and Sweden progress.
4. Goal difference resulting from all three group games.
5. Greater number of goals scored in all group games.
6. Coefficient derived from UEFA EURO 2004 and FIFA 2002 World Cup qualifiers (points obtained divided by number of matches played).
7. Fair play ranking.
8. Drawing of lots by the Committee for the European Championship, only applicable if more than two teams are level.

So, before the two matches took place, even though they were played at the same time, Sweden and Denmark knew that a 2–2 would see them both progress and Italy would be knocked out. Both teams denied any collusion, but the result caused a lot of controversy.

Comments: Even though the rules changed after the Austria vs West Germany match (see Section 3.9.1), playing the final matches at the same time still does not guarantee circumvention that a given result may be beneficial for two teams playing in the same match. A similar situation arose in Euro 2012, again involving Italy. They needed to beat the Republic of Ireland to have any chance of progressing but if Croatia vs Spain ended 2–2, then those two teams would progress. In fact, Italy won, Croatia lost to Spain and Italy progressed. A further example is Chile vs Spain in the 2010 World Cup.

It is difficult to see how these situations can be prevented. Perhaps one way would be to use goal difference (as used in World Cup), as a tie-break rule, rather than the UEFA tie-breaker ordering, although this may lead to further unintended consequences without full analysis. It would be nice if all results could remain secret from the concerned teams, but that is impractical and would introduce its own problems (for example, a team that is guaranteed to progress might want to rest some players).

Just looking at the list of tie-break criteria demonstrates the complexity of trying to cater for every situation and even now, the final arbitrator is to draw lots.

It would be interesting to ask the academic community to propose tie-break rules, which might be based around match statistics (or similar), but without subject to altering incentives that may serve to reduce the spectacle of the game (similar to the Lucas Critique problem in economics).

3.9.4. 25 January 1994, Barbados vs Grenada

Qualifying for the 1994 Caribbean Cup, a regional tournament still in existence today, involved a three-way single round-robin

²⁴ https://www.youtube.com/watch?v=zokUPp_nj_c.

²⁵ http://news.bbc.co.uk/sport2/hi/football/euro_2004/3818337.stm.

Table 8
Group 1 before the final qualifying match of the 1994 Caribbean Cup.

Team	Pld	W	D	L	GF	GA	GD	Pts
Grenada	1	1	0	0	2	0	+2	3
Puerto Rico	2	1	0	1	1	2	-1	3
Barbados	1	0	0	1	0	1	-1	0

format. Only the top team progressed to the tournament finals in Trinidad and Tobago. Before the final match in St. George's, between Barbados and Grenada, Table 8 shows the standings.

The mathematics were simple, Barbados needed to win by two goals to progress, otherwise Grenada would advance. However, the qualifiers had a rule that each match must have a winner, decided in sudden-death extra-time. The goal would count as two. This supposedly simple rule would prove binding in five matches, but in this particular case backfired spectacularly.

Late in the match, Barbados had the 2–0 lead they needed and began playing to merely conserve this lead. Grenada then made it 2–1 in the 83rd minute, which was sufficient for them, forcing Barbados to once again attack. Unable to conjure another goal and with time fast running out, they realized that another (radical) course of action was possible. They scored a deliberate own-goal, the rationale being that (assuming it stayed at 2–2) extra-time would be necessitated, with the opportunity of an additional 30 minutes to score, and in which one goal would both put them two ahead and end the match instantly.

In the final few minutes of regulation time, the state of the match deteriorated even further. The Grenada players quickly worked out that their best response was to score a goal, at either end. This would either win the game or lose by one but at least avoid extra-time. To this end, they headed straight for their own net from the re-start. However, the Barbadians had already anticipated this, so half their players began defending the Grenada goal while the others defended their own. They succeeded in preserving the 2–2 score line at the whistle, and then proceeded to score the winner in the 94th minute, demonstrating a masterclass in perverse-rule exploitation.

FIFA did not penalize the Barbados Federation given that they were striving for the best outcome conditional upon the prevailing rules. Understandably, this rule was never used again.

Comments: Whilst, perhaps, not being obvious when the rule was introduced to motivate the winning of close matches there might have been some benefit in spending some time running through scenarios that may play out. The obvious (in hindsight) cases that need to be considered are those matches that are close, and which have the potential to have an effect as to whether one of the teams progresses or not.

Of course, it is easy to make these type of judgments in hindsight but one wonders how much consultation was carried out and whether the scientific community was asked to comment, perhaps even running simulations to see if any unanticipated effects could arise.

3.9.5. Red and yellow cards

Most football fans would agree that the current yellow/red card sanction system (coupled with penalties) generally does a good job of applying discipline for on-field indiscretions in a uniform and simple manner.

A quarter-final World Cup match between Uruguay vs Ghana on 2 July 2010²⁶ showed that it is not without its shortcomings.

Luis Suárez demonstrated that a shamelessly indiscriminate (and some would argue unsportsmanlike) foul is still worth conceding a penalty and a red card. Late in extra time, with the score at 1–1, Suárez, knowing full well that he would get sent off, instinctively saved the ball (with his hand) on the goal line, preventing an otherwise certain goal²⁷.

In a way it was a totally rational action, because Uruguay would almost certainly be eliminated if he had let the ball go into the net. However, his intervention, even with a man down, meant that if Gyan missed the resulting penalty (which he did), then the contest reverted back to a virtually 50–50 proposition, with penalties being a strong possibility.

Uruguay won the shoot-out 4–2, and despite being without Suárez, they gave the Netherlands a good contest in the semi-final.

Comments: Suárez's actions feel very unsportsmanlike, especially for neutral fans. Thierry Henry in an earlier 2010 World Cup UEFA qualifying playoff at least appeared contrite in the aftermath after a blatant playoff-deciding handball against the Republic of Ireland²⁸.

We would note that not all red and yellow cards are equal. This one had a profound effect on the match, another one (a mistimed tackle late in a match, which had no real consequence) is not as equal. Perhaps the penalties (fine, match bans etc.) should be decided by a panel after the match taking into account the state of the match at the time the offense was committed.

3.9.6. Automatic qualification for FIFA World Cup

Until the 2002 World Cup, the reigning champion was granted automatic qualification for the finals in the next World Cup (as a caveat, Uruguay chose not to participate in 1934). However, the unintended consequence is that this often proved to be more of a curse than a blessing for the reigning champions, which often performed below expectations in the finals. For example:

1. *Brazil – 1974:* Brazil drew the opening match against Yugoslavia, drew the second match against Scotland before beating Zaire in the final group match. This was enough for Brazil to finish in second place and so progressed to the second round of group matches. Brazil lost to the Netherlands before beating East Germany and Argentina. Finishing second in the group, Brazil contested the third place play-off against Poland, losing that match 0–1.
2. *Argentina – 1982:* Argentina lost the opening match to Belgium, winning the next two matches. They finished second in their group. In the second round of group matches, Argentina were beaten by both Italy and Brazil, finishing at the bottom of the group with zero points and a –3 goal difference.
3. *Germany – 1994:* In the first round of group matches, Germany won two games and drew one. This was enough to top the group. In the knockout stages (note, this is a different format to the previously reported tournaments), Germany beat Belgium but then lost to Bulgaria in the quarter-finals.
4. *France – 2002:* In the first round of group matches, France lost two games and drew one, finishing bottom of the group and France's World Cup defense was over.

This rule has now been rescinded (along with pressure by confederations to open up an extra regional qualifying spot). Since then, no reigning champion has failed to qualify for the finals, although Italy performed poorly in the 2010 finals, as did Spain in 2014.

²⁷ <https://www.youtube.com/watch?v=tDpx9GGH79I>, see from about 3 minutes, 15 seconds.

²⁸ <https://www.youtube.com/watch?v=I7slrw1fwA8>.

²⁶ <http://www.fifa.com/worldcup/matches/round=249718/match=300061508/>.

3.9.7. Penalty shoot-outs

It is recognized, though not without dispute (Kocher, Lenz, & Sutter, 2012), that the team shooting first in a penalty shoot-out wins significantly more than 50 percent of the time. This is consistent with serving first in tennis (Magnus & Klaassen, 1999) although, unlike best-of-three sets in tennis, you do not have the luxury of being able to shoot first in the next game.

Palacios-Huerta (2014) devotes an entire chapter to the 1988–89 season of the Argentinian League, in which there existed an unusual points system. All drawn matches went to penalties (no extra-time), with the shoot-out winners getting two points, and the losers one point²⁹. He finds that when players are subjected to shoot-outs in competitive situations much more often than usual, the first-taker advantage disappears. It would be interesting to replicate this study for the 1993–94 Australian domestic season, where something similar applied (except four points for a win to effectively reward regular-time wins)³⁰.

Comments: There is an interesting unpublished paper (Anbarci, Sun, & Ünver, 2015) that considers FIFA penalty shootouts. They note that the team that takes the first penalty is decided by a coin toss, and that this team is more likely to win. A fairer mechanism is proposed based on the Thue–Morse sequence. This does not follow a strict alternating sequence but the team that is behind takes the next penalty. It is noted that this principle is used in the standard rules of Petanque (Boules) and could also be used in other sports such as ice hockey, water polo and handball. It would be interesting to experiment with this idea in a live situation.

3.9.8. The offside rule

The laws of Association Football were written in 1863 (Taylor, 2008), when the Football Association (FA) was formed in London at a meeting in the Freemasons' Tavern. Although there are other important dates in the history of the game, this is the time when most would agree that the formalization of the rules (and establishing of the FA) is probably the most important landmark.

Law 11 of Association Football³¹ defines the offside rule.

The Football Association in the UK provide worked examples of the offside law, by way of an interpretation document³² and FIFA provides guidelines to officials about how to interpret the law³³.

The rationale behind the offside rule is to stop players *goal hanging*. That is, staying in the opponents half, typically near the goal. When a player is passed the ball, the receiving player must have two of the opposing players between themselves and the goal (it used to be three opposing players until the 1920s, and even earlier it was the whole team). This is typically the goalkeeper and a defender. This enables the defending side to *push out* so that the attacking players must retreat back up the field to remain *onside*.

Complications arise as a player can only be offside when the ball is played. So if they time their run correctly, so that they are onside at the time the ball is played, then by the time they receive the ball they may have run many yards past the defender so that they now appear to be offside. To accurately capture whether the player was onside or offside, requires one of the officials (typically the assistant referee) to keep up with play and be in a position to accurately judge whether the attacking player was onside when the pass was made.

Of course, pundits have the benefit of slow (and stop) motion replay and computer technology that can place straight lines across the pitch which is usually able to show whether the correct decision has been made by the officials.

However, this aspect of the rule almost fails into insignificance when one considers whether a player, who is in an offside position is *interfering* with play. The offside rule states:

A player in an offside position is only penalized if, at the moment the ball touches or is played by one of his team, he is, in the opinion of the referee, involved in active play by:

1. *interfering with play or*
2. *interfering with an opponent or*
3. *gaining an advantage by being in that position*

Watch almost any football program and the TV pundits will debate whether a player was interfering with play. There is almost as much discussion as to whether a player, who is on the pitch, can be considered as interfering with play or not, and how can any player not be interfering with play.

Bill Shankly (Liverpool Manager, 1959–1974), commented on the offside rule by saying “*If a player is not interfering with play or seeking to gain an advantage, then he should be.*”

Sweden vs Denmark, 10 August 1948, summer Olympic semi-final: In the 1948 Olympic's semi-final Sweden played Denmark. On a counter attack, Sweden's Gunnar Nordahl realized that he had strayed into an offside position. He removed himself from play by throwing himself into Denmark's goal, no longer being in an offside position. When teammate Henry Carlsson headed a goal a moment later, he even caught the ball before it hit the net³⁴.

Other Olympic examples can be seen in Sections 3.1, 3.3.1 and 3.8.1.

Bulgaria vs Germany, 10 July 1994, World Cup USA 94 quarter-final: A match in the 1994 World Cup between Bulgaria and Germany starkly shows the controversy between a player interfering with play and not interfering with play. A goal by Rudi Völler was, correctly, disallowed by the referee, because he had been in a (passive) offside position a second earlier when teammate Andres Möller shot on goal, but since the shot would rebound off the post straight back to Völler, he was ruled *retrospectively* offside. If the original shot had gone into the goal, it would have stood³⁵.

Comments: The offside rule is often the cause of confusion and controversy. It would be interesting to see the effect of abandoning the rule but this is likely to lead to a *long ball game* and at least one attacking player *goal hanging*, just waiting for the ball to arrive. This would inevitably lead to more defenders having to camp in the penalty area, staying close to the attackers. Overall, abandoning the offside rule would lead to a much more negative game.

Some experiments have been undertaken to try different versions of the offside rule. One experiment³⁶, carried out in the 1973–74 and 1974–75 Scottish League Cup and Drybrough Cup, extended the penalty area line to meet the touch lines, creating a solid line across the pitch 18 yards from each goal. A player could only be offside when inside this area. The experiment was dropped after the 1974–75 season.

In the 1987–88 football conference season the offside rule was changed so that no player could be offside from a free kick³⁷ (footnote 37 also has some other interesting rule changes that were tested). This rule change led to most free kicks resulting in the

²⁹ http://en.wikipedia.org/wiki/1988%E2%80%9389_in_Argentine_football.

³⁰ http://en.wikipedia.org/wiki/1994%E2%80%9395_National_Soccer_League.

³¹ http://www.fifa.com/mm/document/affederation/generic/81/42/36/lawsofthegame_2012_e.pdf.

³² <http://www.thefa.com/football-rules-governance/laws/football-11-11/law-11---offside.aspx>.

³³ http://www.fifa.com/mm/document/afdeveloping/refereeing/law_11_offside_en_47383.pdf.

³⁴ <http://www.fifa.com/tournaments/archive/mensolympic/london2012/news/newsid=1640779/index.html>.

³⁵ <https://www.youtube.com/watch?v=cBuoNKPDk2I>, see from about 3 minutes 0 seconds.

³⁶ <http://sport.stv.tv/football/clubs/celtic/240624-how-the-scottish-fa-tried-to-revolutionise-the-offside-law/>.

³⁷ <http://twohundredpercent.net/?p=25376>.

attacking team all heading into the penalty area, with the ball launched into the sea of attackers and defenders near the goal. The experiment was dropped after a few weeks.

The rule has again, recently, been updated³⁸, and there is a very nice commentary from a former referee that explains what the changes mean.

Some would argue that the offside rule adds a tactical dimension to the game. Defenders have to be much more coordinated if they wish to lay an *offside trap* by the defender(s) pushing up the field at the right moment so that an attacking player is in an offside position just before the ball is played to them. Attackers can also show their skills by timing their runs just right to coincide with midfield players (typically) threading a pass, into the path of a player who has just made their run.

The authors would argue that there is some room for improvement in the rule. Taking our lead from Bill Shankly, we would suggest that any player who is participating in the game can be in an offside position, doing away with any argument about whether a player is interfering with play. To mis-quote Bill Shankly we would argue: “If a player is not interfering with play then what are they doing on the pitch?” Even, if they are tying a boot lace, somebody from the opposing team has to keep an eye on them. Moreover, the Bulgaria vs Germany match (Section 3.9.8) shows that a player not interfering with play one second, certainly can be very soon after. It seems a little unfair on referees having to make these split-second decisions in what is already a tense situation.

However, there are counter arguments to this view. One such example³⁹ is given by Robert Evans, a qualified referee since 1964, who makes some very relevant points, for example should somebody who takes a corner be offside immediately and what does *seeking an advantage* actually mean? The match that Evans refers to in his paper is available on Youtube⁴⁰ (see approximately 3 minutes, 30 seconds), with a discussion on the offside decision being available at askasoccerreferee⁴¹.

In our view the offside rule is still far from clear.

3.9.9. Golden goals

The introduction of sudden-death extra-time (FIFA tried to spin a positive/attacking connotation on it by marketing it as the *golden goal*) was supposed to reduce the incidence of knock-out phase matches going to a penalty shoot-out, as (all other things equal) when a goal (the first) in extra-time was scored, it would deny the team that fell behind in extra-time the subsequent opportunity to equalize, and by extension, the probability that the match would still proceed to a shoot-out. However, while it sounded nice in theory, in a textbook error, FIFA neglected to consider the incentive effects. In denying the opportunity for an equalizer, you also increase the opportunity cost of attacking and conceding a sucker-punch goal, insofar that now that the team no longer gets a chance to equalize. Subsequently, the data showed that this defensive effect ended up overwhelming the positive effect that was evident previously, and not only did extra-time scoring decrease, but the frequency of shoot-outs increased. Brocas and Carrillo (2004) shows how this happened (they also independently look at the effect of the 3-points-for-a-win system). UEFA subsequently experimented with the weaker *silver goal* (the team leading after the first fifteen-minute half would win), but it did not improve the incentives much, so eventually FIFA abandoned the rule and returned to the previous rule.

³⁸ <http://www.skysports.com/football/news/11661/9933613/former-referee-dermot-gallagher-backs-offside-rule-change>.

³⁹ <http://fortheintegrityofsoccer.blogs.com/artandscienceofrefereeing/2009/04/much-ado-about-nothing-and-a-little-history-about-offside.html>.

⁴⁰ <https://www.youtube.com/watch?v=PCZigIXFnBU>.

⁴¹ <http://www.askasoccerreferee.com/?p=2857>.

As mentioned in related work (Section 2), Lenten et al. (2013) suggests that penalties should be taken before extra-time. That would give the necessary incentives (for at least one team) to attack in extra-time.

3.9.10. Full replays for draws

Sometimes a result is required (e.g. in a knockout competition). Until 1991, FA Cup ties were based on unlimited replays (until one team won). In 1975, Fulham played 12 games over six rounds to reach the final, a record which stands to this day. Replays used to be played 3–4 days after the original game, but from 1991–92, this was changed to 10 days, following police advice. This ultimately led to the introduction of penalty shoot-outs if the first full replay is still level after extra-time.

Playing full replays is inconvenient for a number of reasons, with the most obvious being that it can lead to fixture congestion.

Ultimately, there has to be some way of resolving the situation and in the 1968 Euro semi-final between Italy and the USSR, the score was 0–0 after extra time. The winner (Italy) was decided by the toss of a coin, which we suspect, most fans would find a disappointing end to a match.

Possibly, even worse, Turkey qualified for the 1954 World Cup via the drawing of lots after finishing on the same number of points as Spain. A deciding match between the two teams ended in a draw (including extra time), and the drawing of lots went to Turkey. What makes this even more unpalatable is the fact that Spain had a superior goal difference and had beaten Turkey 4–1 in their home fixture, whilst Turkey had only beaten Spain 1–0 in their home fixture.

Of course, there are advantages with a full-replay system, with the major one being extra ticket sales, leading to an unexpected financial windfall.

3.9.11. Fergie time

Fergie time is the so-called extra time bias that is enjoyed by Manchester United, who (perhaps to the biased fan) tend to get more injury time when they needed to score a goal. Fergie is a reference to Manchester United’s long-serving manager, Sir Alex Ferguson, who managed Manchester United for 27 years (1986–2013).

In the mid-1990’s, FIFA compelled match officials to reveal (approximately) how many additional minutes would be played at the start of injury time. This enabled a natural experiment of home bias in referee’s decisions, comparing the revealed minutes with the actual length of play at the referee’s final whistle. In some ways, it is a better test of referee home bias than looking at more standard metrics, such as the number of fouls, as there are potentially numerous selection biases that could explain why away teams commit more fouls than home teams, without a bias being present.

The rule change allowed a comparison showing whether large-market teams benefit more from this *Fergie time* bias than small-market teams. Broadly, the evidence shows that biases do indeed exist, though it is somewhat mixed. Garicano, Palacios-Huerta, and Prendergast (2005) finds that “professional soccer referees favor home teams in order to satisfy the crowds in the stadium. We find that referees systematically favor home teams by shortening close games where the home team is ahead, and lengthening close games where the home team is behind.”

3.9.12. Etiquette

Etiquette is not a law that has to be respected, but is another example of tacit cooperation – both sides have an unwritten contract to respect the etiquette. Some breaches are more serious than others. Not to show new balls to an opponent in tennis is probably not that serious. To deliver a punch, rather than shake hands (or at least touch gloves), at the start of the final round in a boxing

match might be viewed more seriously. To break the *laws of etiquette* does not break the laws of the game but some would see it as being equally as bad, or even worse, as it is also a breach of trust.

In football, it is quite normal that a player will kick the ball into touch so that an injured player (even an opposing player) can receive treatment. When play resumes, the person taking the throw in will return the ball to the opposing team. To do this is not a law of the game, but is observed widely, if albeit not universally.

On 13 February 1999, Arsenal were playing Sheffield United in the FA Cup fifth round. With the score at 1–1, a Sheffield player (Lee Morris) went down injured and the ball was put out of play by the United goalkeeper. When play resumed Ray Parlour took the throw-in, throwing it towards the United end. However, Arsenal's Nwankwo Kanu intercepted the throw and passed the ball to Marc Overmars who knocked it into the net, to score the winning goal⁴². Sheffield United's players, were naturally very upset, but the referee had to award the goal. Kanu's defense was that it was his first game in England and he misunderstood the situation. Arsenal's manager, Arsène Wenger, contacted his counterpart (Steve Bruce) and offered to replay the game. The FA raised no objections so the match was voided, with Arsenal winning the rescheduled match.

On 8 August 2015, Doncaster were playing Bury in a League One (third tier) fixture. After an injury, a throw-in was given to a Doncaster player, who lobbed in back to the Bury goalkeeper, but the ball bounced over the goalkeeper's head and went into the goal. The referee had to let the goal stand. The two teams conferred and Bury were allowed to score an unopposed walk-in from the kick off⁴³.

Comments: In both of these incidents, there could have been unintended consequences. For example, some goalkeepers have a clean-sheet bonus in their contracts and goals from these type of incidents could spoil that record. It could also affect league standings at the end of the season, if two teams are on the same number of points and the final league position is decided by goal difference or by goals scored. Of course, it could work to the advantage of one of the teams and, perhaps, disadvantage another team who was not involved in the original incident.

Perhaps there is an argument that a referee should have the discretion to disallow a goal for reasons of etiquette (should both captains agree), although this, in itself, is likely to lead to controversial incidents.

We would also note that etiquette could also be seen as good sportsmanship, although there might be subtle distinctions. Etiquette is a set of unwritten, but widely accepted, rules which even unsportsmanlike athletes still subscribe to due to peer pressure. Being a good sportsman is more about an attitude and wanting to play all aspects of the games in a fair way. Another area which we would argue is different to etiquette is *fair play*. This can be defined as “*doing anything morally 'wrong' to gain an advantage to win.*” This could be categorized as acceptable (e.g. negative or dour/defensive tactics but playing within the spirit of the game), unacceptable and against the spirit of the game, although ‘legal’ (e.g. sledging), and against the rules (e.g. doping, sabotaging an opponent).

3.10. Formula One

In the 2016 Australian Grand Prix, the qualifying system was criticized after rule changes were introduced, governing the use of tires⁴⁴. The Independent newspaper reported “*The one-hour session*

will be remembered as a farce with no cars on track in the final minutes of the knockout session, leading Mercedes boss Toto Wolff to describe it as 'rubbish'.”⁴⁵ The incident happened as one of the teams decided to save their tires for the main race. Other teams followed their lead, which led to fans staring at an empty track for the final few minutes.

Mercede's Toto Wolff is reported as saying “*We need to discuss it. Everyone is trying to do their best to improve the show and if we haven't we need to discuss it. The solution is not good in my opinion and that is why we have to look at it again.*”

3.11. Hockey

3.11.1. NHL points system/scoring

From 1983–84, the NHL used to have ties if overtime failed to separate the teams, with two points for a win, one for a tie, and zero for a loss. From 1999–2000, that was changed such that the overtime loser was then awarded one point. From 2005–2006, a skater came off from each side, leaving it 4-on-4. This opens up the field increasing the likelihood of scoring. As of the 2015–16 season, overtime is now 3-on-3. For years, ties had been becoming more frequent, and administrators felt that this measure would provide an incentive to prevent defensive play in overtime; but the incentive-effect of this change proved to be two-fold. It (largely unforeseen) perversely encouraged more defensive play in the final few minutes of matches in which the scores were level, as both teams knew if it stayed that way until the end of regulation time, the joint reward would ultimately improve from two points to three points, regardless of what happened subsequently. Following the ‘lockout’ season, since 2005–06, if a game was not decided in overtime, a (kind of) penalty shootout would determine the winner (still with a 2–1 split). *Abrevaya (2004)* is one the papers that investigates this rule change, noting that “*the rule change had the desired effect of increasing excitement during overtime play. This article shows, however, that the rule also had the effect of increasing the frequency of overtime games, an effect predictable from the change in incentives but one not intended by the league.*” The NHL persists with that competition points system.

NHL is also discussed in [Section 4.1](#), item 1.

3.11.2. Tanking in hockey

In the 2015 IIHF Ice Hockey World Championship, Finland and Russia were both through to the quarter-finals. The loser of this game would stay in Ostrava and play Sweden, whereas the winner had to travel to Prague to play the hosts (Czech Republic). Apparently, it was clear to everyone watching the match exactly which alternative was preferred by both teams. Neither authors know enough about ice hockey to offer a strong opinion but the highlights are available on Youtube⁴⁶, so that more knowledgeable readers can form their own opinion. Tanking in other sports is discussed in [Sections 3.3.1, 3.6, 3.12.2](#) and [4.1](#) (Point 1).

3.12. Tennis

3.12.1. Challenging your own serve in tennis

The final of the Australian Open (29 January 2012) was between Novak Djokovic and Rafael Nadal. It was an excellent match, that will be remembered by tennis fans for many reasons. However, there was a strange incident that did not change the outcome of the match, but a similar incident could do so in different circumstances.

⁴² <https://www.youtube.com/watch?v=whO5GAFBp30>.

⁴³ <https://www.youtube.com/watch?v=ut6B91bN2m8>.

⁴⁴ <http://www.autosport.com/news/report.php/id/122220>.

⁴⁵ <http://www.independent.co.uk/sport/motor-racing/australian-grand-prix-2016-rubbish-qualifying-system-criticised-as-lewis-hamilton-continues-pole-a6940761.html>.

⁴⁶ <https://www.youtube.com/watch?v=W3FpqJrB0RE>.

Nadal challenged the validity of one of his own serves. The serve was judged to be in, but Nadal questioned whether it was out. The Hawk-eye system showed that the ball was only just in, so the point, as played, stood.

Why does this matter? When Nadal served, Djokovic hit a winning return. If the challenge had been upheld (i.e. the ball was called out) then the server would get a second serve and may win the point. At a more critical point in the match, this could have had significant consequences.

There are other examples of this⁴⁷ and even examples where it has been successful⁴⁸.

Comments: At first sight it appears questionable whether you should allow a challenge to be made by a server when they are given the decision they would normally desire. If the serve was an ace, or they thought that they would win the point, they would be unlikely to challenge the serve. The problem is that if a winning return is made, the server can always argue that they had no time before the return to make the challenge, so they can only challenge at that point – with the benefit of hindsight.

No doubt the authorities have considered this rule but for it to be changed, requires an actual case where this occurs on a critical point, such as a match point, where the server challenges, it is upheld and goes onto win the match. We suppose that the counter argument is that under these conditions, the server does deserve a second serve.

One suggestion is that the players have to decide *before* the match whether they want all of their serves scrutinized by Hawk-eye and if a first serve is in, but called incorrectly, then the server has to take a second serve. However, we suspect that this would be too cumbersome to implement.

Researchers have started to look at optimal *challenge strategies* (Abramitzky, Einav, Kolkowitz, & Mill, 2012; Clarke & Norman, 2012) as competitors get more used to them, and they seem to be used in more sports.

3.12.2. Tanking in tennis

There is potential for tanking story in tennis. The following incident relates to the ATP/WTA ‘Lucky Loser’ rule: “A lucky loser is a sports player who loses a match in the qualifying round of a knockout tournament, but who then enters the main draw when another player withdraws after the tournament has started because of illness, injury or other reason”.

The lucky loser then enters the main draw, normally in place of the withdrawn player. This can only happen before all players in the main draw have started their first match in the tournament. In tennis, the traditional rule for choosing a player to enter the main draw as a lucky loser is as follows.

From all players eliminated in the final round of qualifying, the highest-ranked player in the ATP or WTA rankings is the first one to enter the draw, followed by the second highest-ranked player and so on (if more players withdrew before the start of the tournament). On rare occasions when there are more late withdrawals than losers in the last qualifying rounds, or players eligible for lucky losers are not available, a player who lost in the penultimate round of qualifying may qualify as a lucky loser. Prior to the 2005 Wimbledon Championships, American player Justin Gimelstob faced George Bastl from Switzerland in the final qualification round. Gimelstob, who was the highest-ranked player remaining in the qualifying tournament, aggravated a chronic back complaint during his second qualification match against Vladimir Voltchkov. Gimelstob planned to withdraw before the match with Bastl, and informed his opponent of his intent. However, officials suggested

that Gimelstob play at least one game, as it was almost certain someone would withdraw from the main draw before the tournament started, giving Gimelstob a good chance of getting a lucky loser place, as well as giving him time for his back to recover.

Gimelstob did indeed enter the main draw as a lucky loser after the withdrawal of Andre Agassi, reaching the third round, where he lost to Lleyton Hewitt. While Gimelstob’s behavior was not generally considered unethical, it raised concerns by pointing out that any player in a similar position would have little incentive to play a competitive match. For example, a high-ranking player paired against a lower-ranked friend might deliberately lose the match to help his friend gain entry to the tournament, if the first player had already been given a lucky loser spot. The possibility of bribery was also a concern.

Shortly after, a new policy was introduced in Grand Slam tournaments. Since 2006, the four highest ranked players who lose in the last round of qualification take part in a four-way random draw, the results of which are used to determine the order in which each player will enter the main draw. Consequently, if only one main draw spot for a lucky loser is available, the highest-ranked loser has just a 25 percent chance of entering the draw, instead of 100 percent as previously. This element of uncertainty helps to ensure that final-round qualifying matches remain competitive. However, this rule does not apply in all other tournaments.

Fortunately, due to this minor incident, the administrators foresaw the scope for a major incident and changed the rule before a major incident could occur.

Tanking in other sports is discussed in Sections 3.3.1, 3.6, 3.11.2 and 4.1 (Point 1).

3.13. National Football League: NFL

3.13.1. NFL overtime/scoring

The NFL has had (single) sudden-death overtime for drawn/tied matches since 1974, extending further (if necessary) for playoff matches. It had long been found however, that winning the toss to get first possession (by forcing the opposition to kick-off), means that the winner of the toss ends up winning the match nearly 60 percent of the time. Wanting the toss to have less influence, the NFL altered the rule so that if Team A scores a field goal on their first possession, Team B now gets one possession themselves to at least match Team A’s score, with overtime continuing if team B also scores a field goal. The rule has not yet been binding on a sufficient number of occasions to make reliable inference on its performance.

Related to this scenario, Che and Hendershott (2008) suggested a *Yardage Auction* to overcome the same problem. Despite being an interesting idea, it is unlikely that the League administrators would adopt it for aesthetic, mechanical, and/or operational reasons.

3.14. Rugby

3.14.1. National Rugby League: golden point

Similar to both to the NFL (see Section 3.13.1) and the golden goal (see Section 3.9.9), the National Rugby League (NRL, Australia’s elite Rugby League competition) introduced a sudden-death extra-time in 2003⁴⁹. As at 1 April 2016, of the 92 matches that have gone to extra-time (including the 2015 Grand Final), 79 were decided by a golden point, thus reducing the frequency of draws by more than 85 percent. However, of more contention is how teams tend to play extra-time. Many of these contests are dry and methodical, typically with both teams angling a field goal (worth

⁴⁷ <https://www.youtube.com/watch?v=AWFPcjKlzeU>.

⁴⁸ <https://www.youtube.com/watch?v=OJIH6qFAZrU>.

⁴⁹ http://en.wikipedia.org/wiki/Golden_point.

only one point) as their scoring method of first choice. Of the 79 matches decided, 52 (almost two-thirds) were won with a field goal, with 18 via a try and nine by way of a penalty goal. We cannot recall any discussion about the winning of the toss angle (as in the NFL), but it would not be a surprise if the figures bear that out.

3.14.2. Rugby (union) bonus points

In the 2012 Rugby Championship, game 1, Australia were playing New Zealand (Sydney, 18 August)⁵⁰. The match is available on YouTube⁵¹ (see approximately, 1 hour, 43 minutes). At 19–24 down, on the stroke of full-time, Australia conceded a penalty close to the New Zealand try line. If bonus points did not exist, New Zealand would likely simply kick the ball into touch to finish the game. If they took the penalty attempt, there would be the chance that it rebounded off the post back into general play, from which Australia could have run it down to the other end for a (converted) try and steal the game. However, with bonus points, New Zealand skipper Richie McCaw decided that the albeit minimal risk was worth taking. By converting the penalty (which would be the very last play), the final score would be 19–27, thus Australia would be denied the (narrow-loss) bonus point; which in the context of the tournament might have proved later to be useful. Dan Carter converted the kick, and indeed the New Zealand decision proved to be the correct one.

3.14.3. 1995 National Provincial Championship, Otago vs Auckland

In 1995, in a National Provincial Championship game, Auckland were leading Otago by seven points. Towards the end of the game Otago were awarded a penalty close to Auckland's goal line. The narrow-loss bonus was awarded for losing by six, or fewer, points. With this in mind, rather than go for a try/conversion in order to draw the game, Otago decided to take a penalty kick (which was successful).

From an expected-points perspective this was the right thing to do, but from a rules points of view, it is interesting to note that they were encouraged to accept a loss, rather than try for a draw. We suspect that this rule was designed to encourage teams that are behind to try harder towards the latter end of the game, and so maintain spectator interest.

4. Examples from multiple sports

4.1. Salary caps and player drafts

The two main policy tools that the big-four 'Major Leagues' in North American (and Australian) sports use to try to enhance competitive balance (and also, keep players' wages low) are the salary cap and player drafts. Their collective effectiveness on competitive balance is debatable, but these policies can sometimes incentive perverse behavior. We present some of these below.

1. With player drafts, the traditional set-up is reverse order, so as to supposedly maximize the potential of its otherwise randomness to even up the competition over time, as cellar-dwellers are advantaged. Quoting from Lenten (2016) "... allocate the first pick from the talent pool to the team with the least amount of talent, providing it with the best opportunity to improve its rank in subsequent seasons."

This creates a perverse incentive for some teams to 'tank' once they are eliminated from playoff contention, because "...losing is linked to the prospect of a higher-order pick from the annual

pool of available and/or emerging talent. The perverse incentives are at their strongest during the latter stages of the regular season for teams that already face a weakened win-incentive following expiration of playoff qualification likelihood."

The tanking problem is discussed in all the major US/Canadian sports, with it anecdotally being at its most acute in the NBA, which (quoting again from Lenten, 2016): "...introduced a 'lottery' system the top pick is drawn randomly, with probabilities weighted progressively towards lower-ranked teams in 1984 (the NHL..., followed suit in 2007), weakening the negative correlation between final rank and pick order."

The lottery probability structure has been changed a few times since, see Price, Soebbing, Berri, and Humphreys (2010).

Despite perennial accusations of NBA teams tanking, we cannot find a single case of a team being charged as such. In fact, the only case we could find was again in the AFL; a scandal involving Melbourne on the basis of matches in 2007 and 2009, though it worth noting that they were not charged formally with 'tanking' (there was not enough evidence for this), but rather for 'bringing the game into disrepute', and so were the then-coach (now deceased) and his assistant coach⁵². It is also worth noting in this case, the exact nature of the Melbourne games had to do not with purely the reverse-order draft, but rather a 'priority pick', an AFL draft nuance that provides a further layer of perverse incentive to tank⁵³.

Details of a specific match, also involving Melbourne, but not part of the scandal itself is presented here. Ironically, they won this game, but principally because the other team had an even stronger incentive to tank.

2 September 2007 (Round 22) - Melbourne vs Carlton, MCG⁵⁴.

The Round 22, 2007 match between Melbourne and Carlton, nicknamed the 'Kreuzer Cup', was the most controversial match in the tanking debate. It was the last match of the year, and both Melbourne and Carlton had a record of 4–0–17 (W–D–L), meaning that whichever team won the match would lose the chance at a priority draft pick, and both clubs had already avoided the ignominy of the wooden spoon, as Richmond had already secured it with a final record of 3–1–18.

This meant that there was no benefit for either club to win, but a significant benefit in losing. The stakes were particularly high in Carlton's case, because the club had also received a priority pick in the 2006 season. As such, if it lost this match, it would receive the No. 1 draft pick as its priority pick. In Melbourne's case, the priority pick it could have received would be the No. 18 pick; the No. 1 pick would go to Richmond if Melbourne lost the match. The match became known as the Kreuzer Cup, named after Northern Knights' ruckman Matthew Kreuzer, who had been expected to be selected with the No. 1 pick in the 2007 AFL Draft. The match was high scoring, played with low intensity, poor skills and very little defensive pressure, and two players (Carlton's Heath Scotland and Melbourne's Travis Johnstone) gathered more than 40 disposals. In addition, the crowd of 26,156 was subdued, and there were reports of fans openly supporting the opponents. In the end, Melbourne had a five goal lead by quarter time, and ended up winning 21.13 (139) to 15.18 (108). Carlton went on to recruit Kreuzer with the No. 1 pick in the draft.

The only footage we could find of the game is from a chat show several years later (the whole clip is interesting, but the game footage is from about 3:45–4:20)⁵⁵.

⁵⁰ <http://www.espnscrum.com/the-rugby-championship/rugby/match/153845.html>.

⁵¹ <https://www.youtube.com/watch?v=qeqhQblge8Q>.

⁵² http://en.wikipedia.org/wiki/Melbourne_Football_Club_tanking_scandal.

⁵³ http://en.wikipedia.org/wiki/Priority_draft_pick#Tanking.

⁵⁴ <http://afltables.com/afl/stats/games/2007/031120070902.html>.

⁵⁵ <https://www.youtube.com/watch?v=lij30ApCgFk>.

Tanking in other sports is discussed in Sections 3.3.1, 3.6, 3.11.2 and 3.12.2.

2. With salary caps, apart from the economic problems it brings (that the allocation of players is not optimal, and that star players and large-market teams both have incentives to get around it), the more specific problem is that it is there to be cheated, especially when it is a ‘hard’ salary cap. As an example, salary cap breaches were in force in the NRL (National Rugby League in Australia) in 2010, when Melbourne Storm had two past titles (2007 and 2009) stripped, plus other penalties⁵⁶. This followed another, not quite as significant, breach by Canterbury-Bankstown in 2002 in which they were stripped of all their points in the current season and finished bottom⁵⁷. In the same year, the AFL (Australian Football League) also experienced its salary cap cheating scandal, involving Carlton (who have seemingly still not yet recovered from it). Comprehensive lists of NRL and AFL breaches (mostly minor) are available^{58, 59}. The main difference between the leagues is that since the AFL also has a draft (unlike the NRL), the penalties tend to focus on stripping draft picks (which are forward-looking), whereas the NRL do not have that penalty at their disposal, thus stripping of points (which is backward-looking) is their penalty of choice.

Tanking in other sports is discussed in Sections 3.3.1, 3.6, 3.11.2 and 3.12.2.

4.2. Tournament formats

1. Similar to appeasing India in cricket (see Section 3.7.4), the Rugby World Cup has an unusual number of competing teams (20). Why 20? We suspect that adding an extra four teams, from the 1999 competition, means that there is a justification for an extra place going to the Americas, which in turn means almost certain qualification for the USA. Is this an example of economic factors being given more weight than the ‘optimal’ number of teams?
2. Managing the tournament design for economic incentives is part of FIFA’s strategy, above and beyond gifting World Cup hosting rights to countries with no previous pedigree, such as USA, Japan and Qatar – although the argument would be made that this is to give opportunity to countries with potential/aspiration. It is recognized that FIFA often changes its system to determine the seven (excluding the hosts) group seeds for each tournament, with 2010 and 2014 being exceptions. In those years the seedings were done by considering the most recent rankings. Choosing a ‘system’ that FIFA openly reports, to give it legitimacy, is often seen as being chosen to provide seedings to as many as possible of the big media markets, so that they are not drawn in the same group. For example, the 2006 system seems overly complex for something that should appear to be reasonably simple⁶⁰. A similar system had been used in 2002⁶¹, but with subtly different weightings. There was some controversy before the 2014 World Cup draw, when FIFA decided upon their allocation of the draw pots. Only eight teams were seeded; the hosts (Brazil) and the seven sides ranked highest in the October 2013 FIFA World Rankings (Spain,

Germany, Argentina, Columbia, Belgium, Uruguay and Switzerland). The remaining teams were allocated to three pots based on their geographical location. However, there were still nine unseeded European sides. This meant that one European side had to be allocated to Pot 2, comprising of African and South American sides. FIFA decided that the European team in Pot 2 would be chosen randomly (which turned out to be Italy) from those in Pot 4.

Many assumed, based on a 2006 precedent, that it would be France that would be moved, and not a random choice. This assumption was based on France being the lowest-ranked European side in the October 2013 FIFA World Rankings, which was used to determine the eight seeded sides.

Many officials, fans and journalists complained, pointing out that a Frenchman, the FIFA secretary-general Jérôme Valcke, had suggested the change, also suspecting that another influential Frenchman, UEFA’s president Michel Platini, had helped it get approved. The next day, a headline in the Italian sports periodical *Corriere dello sport* read “2014 World Cup draw: What a scandal!”.

A similar situation arose with the 2006 seeding. On that occasion the lowest-ranked European side (Serbia and Montenegro) were placed in the alternative pot.

3. The Davis Cup until 1972 had a curious design, called the ‘challenge’ system, in which the reigning champion went straight into the Final the following year with home-court advantage. This is antiquated by the standards in modern professional tennis and numerous other sports, although systems like this still exist in sports such as chess.
4. In the Sheffield Shield, they have recently re-introduced a ‘bonus point’ system⁶². Compared to the previous system, it favors teams that play the game ‘quicker’; higher batting run rates and lower bowling strike rates. This (arguably unfairly) favors Western Australia, which plays on its traditionally hard and bouncy pitch. A previous bonus point system existed throughout the 1970s, a period in which Western Australia dominated. This domination continued after the points system was reformed, right up until the early 1990s, when all the other teams finally adjusted to more attacking tactics, in line with the incentives inherent in the competition points system. We suspect that this also resulted in the Australian team itself becoming a lot more attacking from the mid-1990s onwards.
5. Under the North American conference and divisional system, it is well known (and accepted) that some teams qualify for the playoffs ahead of other teams that have actually won more matches (or accumulated more points). In some rugby (and cricket) tournaments, this is also possible due to the existence of bonus points. One further curiosity lies in the Scottish Professional Football League (SPFL) since 2000–01, whereby this can also happen, but by virtue of an idiosyncrasy seldom seen elsewhere. Specifically, the table is ‘split’ into its top and bottom halves after three full round-robins, and then no crossover is allowed in the last five rounds of matches. In a number of seasons, some teams finish above other teams that have more points. In the 2002–03 season, seventh and eighth both accumulated more points than the teams that finished fifth and sixth⁶³.

5. Conclusion

The vast majority of people probably think that the rules that govern the major sports are fairly static, with changes only being

⁵⁶ http://en.wikipedia.org/wiki/Melbourne_Storm_salary_cap_breach.

⁵⁷ http://en.wikipedia.org/wiki/2002_Bulldogs_RLFC_season#Salary_cap_breach.

⁵⁸ http://en.wikipedia.org/wiki/National_Rugby_League_salary_cap.

⁵⁹ http://en.wikipedia.org/wiki/AFL_salary_cap.

⁶⁰ http://en.wikipedia.org/wiki/2006_FIFA_World_Cup_seeding.

⁶¹ https://en.wikipedia.org/wiki/2002_FIFA_World_Cup_seeding.

⁶² http://en.wikipedia.org/wiki/Sheffield_Shield.

⁶³ http://en.wikipedia.org/wiki/2002%E2%80%9303_Scottish_Premier_League.

rarely made. It is the case that many sports rarely change their rules, but many others are under constant development and that the changes sometimes lead to unintended consequences. Indeed, even long established rules can sometimes still have undesirable effects.

Many of the rule changes highlighted in this paper are aimed at making the sporting event more exciting. These are the ones that often lead to an unexpected occurrence which was not foreseen, even if it has the desired effect for the vast majority of the time.

Other rules have been exploited through tanking. We would argue that tanking is always unacceptable and that any rule that provides an incentive to tank is a poor rule. The practical realities of the sports industry is that the business model depends on athletes always trying their best, as that is the way it is sold to the public. There are also integrity issues, not least of all betting markets and possible match-fixing implications. We would expect sports administrators to say that tanking is always bad, and for the purpose of academic discourse contributing to effective governance of the sports industry, if they say tanking is unacceptable, this is sufficient for papers such as this to report it, and find ways to circumvent it.

On the issue of tanking, we would like to make a final comment. If a team is trying to lose as a means to get some later benefit (e.g. easier next-round opponent, higher draft pick, etc.), then that is always unacceptable. If, next year, the current English Premier League champions were to win the title again with two games left and decided to rest players, it could be argued that they have every right to do this. Indeed, each team has a squad of players and, in our view, the manager can use these players as he/she sees fit. Therefore, we would not regard this as tanking, but as using available resources to meet the longer term aims of the club.

Other changes are concerned with tournament structures, often in the ways draws are made to get certain teams (or groups of teams, for example continents) to be in the same group, or to stop them being in the same group. These rule changes are less about the sport itself but more concerned with giving underdogs a better chance than they otherwise might have had, or to ensure that certain teams have a good chance of progressing in order to protect TV and advertising revenue.

Other rules are aimed at making the length of a sporting event more predictable, or ensuring that there is a winner without requiring a full replay. These rules are also the ones that are likely to lead to undesirable outcomes.

We are grateful to Mike Wright for publishing his invited review (Wright, 2014) of sporting rules from an OR perspective, and for his suggestion that what he covered was just the start of many other studies. We hope that this one is the first of many that addresses this important issue, as sports affects so many people's lives and has an economic impact in many regions and countries.

As we said in the introduction, the topic addressed by this paper is comprehensive, but not exhaustive. Even while revising this paper, we came across some recent examples where rules were either having unintended consequences or the authorities were proposing changes:

1. In the U17 2016 Euro qualifying competition⁶⁴. There was a scenario whereby two teams would be better off with a score draw than either side winning.
2. The NRL are reconsidering the 'golden point' rule⁶⁵. In last year's Grand Final, decided by golden point, North Queensland got the winning field goal on their first set in extra time, mean-

ing that Brisbane did not get a chance to respond, partly their own fault because of a handling error from the kick-off. The NRL are considering adopting a similar model to the NFL (see Section 3.13.1). This would mean that a team would have a 'full set of six' to respond after conceding a field goal.

3. The AFL has scrapped the full Grand Final replay if it is drawn⁶⁶. A draw has only happened three times since the foundation of the League in 1897: in 1948, 1977 and 2010 (each time with all-Melbourne based teams). As the Grand Final is always played at the Melbourne cricket ground irrespective of the teams that make it in the now-national competition, the interstate teams (especially Fremantle) were pushing hard for this change for quite a while, as they felt it unfair that they would have to travel coast-to-coast a second time.

We hope that other researchers add to the literature where sporting rules have not had the consequences that the sports' administrators desired. Moreover, this is an interdisciplinary area covering OR, economics, business, game theory etc., as well as impacting on the industry itself, governments, policy makers and the international committees that govern sports.

We hope that one consequence of this paper is that the scientific community and the sports industry can work more closely together in order to study the effects of potential rule changes before they are implemented, or implemented in such a way that they can be studied before wider adoption. As a call to action, perhaps the governing bodies of the major sports could invite academic representatives onto their committees, who would be tasked with identifying possible loopholes in proposed rule changes, perhaps in consultation with the wider scientific community. Alternatively, proposed rule changes could be posted in a public forum and interested academics could comment, perhaps after running simulations?

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⁶⁴ https://www.reddit.com/r/soccer/comments/4d5ki3/theres_a_bizarre_situation_in_u17_euro_2016/.

⁶⁵ <http://www.abc.net.au/news/2016-04-19/golden-point-may-get-the-boot/7336746>.

⁶⁶ <http://www.afl.com.au/news/2016-04-19/no-more-grand-final-replays>.

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