



Innovative Applications of O.R.

A study of the powerplay in one-day cricket<sup>☆</sup>Rajitha M. Silva<sup>a</sup>, Ananda B.W. Manage<sup>b</sup>, Tim B. Swartz<sup>a,\*</sup><sup>a</sup> Department of Statistics and Actuarial Science, Simon Fraser University, 8888 University Drive, Burnaby, BC V5A 1S6, Canada<sup>b</sup> Department of Mathematics and Statistics, Sam Houston State University, Huntsville, TX 77340, United States

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## ABSTRACT

This paper investigates the powerplay in one-day cricket. The rules concerning the powerplay have been tinkered with over the years, and therefore the primary motivation of the paper is the assessment of the impact of the powerplay with respect to scoring. The form of the analysis takes a “what if” approach where powerplay outcomes are substituted with what might have happened had there been no powerplay. This leads to a paired comparisons setting consisting of actual matches and hypothetical parallel matches where outcomes are imputed during the powerplay period. Some of our findings include (a) the various forms of the powerplay which have been adopted over the years have different effects, (b) recent versions of the powerplay provide an advantage to the batting side, (c) more wickets also occur during the powerplay than had there been no powerplay and (d) there is some effect in run production due to the over where the powerplay is initiated. We also investigate individual batsmen and bowlers and their performances during the powerplay.

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## 1. Introduction

In the major sports of the world, rule changes are typically considered with great care. For example, FIFA (Fédération Internationale de Football Association) has made very few significant rule changes in soccer over the last 44 years (<http://www.fifa.com>). In 1992, legislation was introduced whereby goalkeepers were henceforth forbidden from handling back-passes. The only other significant rule change in soccer during the period concerned the offside rule. The offside rule has been twice liberalized (1995 and 2005) whereby offsides are now less common. Similarly, baseball is a sport steeped in tradition where there is a reluctance to alter the way that the game is played. In Major League Baseball (MLB), one may point to the introduction of the designated hitter in 1973 as the most recent significant rule change (<http://www.baseball-almanac.com/rulechng.shtml>). Wright (2014) provides a survey of the analysis of sporting rules from the perspective of operational research (OR).

In contrast to the stability of rules (laws) involving many of the major sports, one-day cricket has tinkered continuously with its powerplay rule. One-day cricket was introduced in the 1960s as an alternative to traditional forms of cricket that can take up to 5 days to

complete. With more aggressive batting, colorful uniforms and fewer matches ending in draws, one-day cricket has become very popular. In the early days of one-day cricket, fielding restrictions were introduced as an additional strategy for making the game more exciting and popular. In simple terms, the powerplay imposes fielding restrictions that encourages aggressive batting and the scoring of runs. More specifically, fielding restrictions on the bowling team are in place during the full 50 overs of an innings. During powerplay overs, the level of fielding restrictions is increased whereby there are fewer fielders allowed in the outfield which may encourage the batting team to play more attacking type shots.

Although fielding restrictions have existed in one-day cricket since the 1996 World Cup, the term “powerplay” was introduced by the International Cricket Council (ICC) in 2005. And since 2005, there have been four distinct implementations of the powerplay rule. This paper investigates the four versions with a specific focus on whether powerplays really do increase run production. Although it may appear self-evident that run scoring increases during the powerplay, it is conceivable that aggressive batting leads to more wickets which in turn results in fewer runs. This is the line of reasoning which has initiated our investigation.

There are various practical questions associated with our investigation. For example, is the run scoring and wicket taking properties associated with the powerplay in line with the desires of the ICC? Also, in-game wagering has become extremely popular with on-line sportsbooks (<http://bleacherreport.com/articles/54254>). Accordingly, are in-game wagering odds properly reflected by the onset of the powerplay? Other questions involve strategic implications of

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\* Corresponding author. Tel.: +1 778 782 4579.

E-mail address: [tim@stat.sfu.ca](mailto:tim@stat.sfu.ca), [tim@cs.sfu.ca](mailto:tim@cs.sfu.ca) (T. B. Swartz).

the powerplay. For example, in what over should a team invoke the powerplay? Moreover, is an individual's level of batting aggressiveness appropriate during the powerplay?

To our knowledge, there have not been any previous investigations on the effect of the powerplay. However, there are many data analytic studies concerning one-day cricket that have an OR focus. To get a sense of the variety of problems that have been addressed in one-day cricket, we mention a few recent papers. Most notably, Duckworth and Lewis (2004) developed the standard approach for the resetting of targets in rain interrupted matches. The approach known as the “Duckworth–Lewis method” has been adopted by all prominent cricketing boards and is based on the concept of resources which is a function of overs remaining and wickets taken. Following the seminal work of Duckworth and Lewis (2004), there have been various modifications and proposals for the resetting of targets (e.g. McHale & Asif, 2013). Various authors including Allsopp and Clarke (2004) and Fernando, Manage, and Scariano (2013) have investigated the effect of the home team advantage in one-day cricket. This is obviously important for match prediction. A topic of interest in every sport is player evaluation. Whereas in some sports, the measurement is straightforward, cricket performance involves a combination of batting, bowling and fielding contributions. In limited overs cricket, van Staden (2009) developed some simple and intuitive graphical displays to investigate batting and bowling performances. Valero and Swartz (2012) dispelled the myth that there are synergies in opening partnerships. It is argued that batsmen are not affected by the performance of their partners. Team selection is a problem of real interest to cricketing sides. Lemmer (2013) considered integer optimization methods for team selection. Swartz, Gill, Beaudoin, and de Silva (2006) extended the problem to the determination of optimal batting orders using a simulated annealing algorithm. Norton and Phatarfod (2008) used dynamic programming to produce an optimal run scoring strategy for the batting team in both the first and second innings.

In Section 2, the data are introduced and the four historical versions of the powerplay are described. Section 3 is concerned with the construction of hypothetical parallel matches. We take a “what if” approach where powerplay outcomes are substituted with what might have happened had there been no powerplay. This leads to a paired comparisons setting consisting of actual matches and parallel matches where outcomes are imputed during the powerplay period. Section 4 carries out the powerplay analyses by comparing the actual matches with the parallel matches. We investigate the difference in run production and the number of wickets taken with respect to the various powerplay rules. We also investigate the difference in run production with respect to the over where the powerplay was initiated. Section 5 provides a Bayesian analysis of individual batsmen and their ability to take advantage of the powerplay. We then do likewise for bowlers. We conclude with a short discussion in Section 6.

## 2. Data and history of the powerplay

For the analysis, we considered all ODI (one-day international) matches that took place from July 7, 2005 until the end of 2013 which involved full member nations of the International Cricket Council (ICC). Currently, the 10 full members of the ICC are Australia, Bangladesh, England, India, New Zealand, Pakistan, South Africa, Sri Lanka, West Indies and Zimbabwe. Details from these matches can be found via the Archive link at the CricInfo website (<http://www.espncricinfo.com>).

For these matches, only first innings data were considered. The rationale is that we want to study the powerplay under baseline circumstances. A team's batting behavior (aggressive versus passive) in the second innings depends largely on the target score that was established in the first innings. We excluded matches that were discontinued or were shortened to less than 50 overs. We also excluded

197 matches where we were unsure about the starting and ending points of the powerplay. In total, we were left with 597 matches involving reliable full first innings data.

For the imputation methods of Section 3, we require detailed batting results, at the level of balls bowled. This information does not appear to be generally available in a convenient format. Hence, a proprietary R-script was developed and used to parse and extract ball-by-ball information from the Match Commentaries. For each first innings, we have two rows of data with 300 columns. In the  $j$ th column of the first row, we record the number of runs scored on the  $j$ th ball bowled (with extras included). In the  $j$ th column of the second row, we record either 0/1 according to whether a wicket was taken on the  $j$ th ball bowled. Some additional columns were also recorded such as the match identifier, the batting team, the bowling team and the beginning and ending over for the batting powerplay. This results in a large dataset with  $2(597) = 1194$  rows and 305 columns.

We now review the various historical implementations of the powerplay during the period of study, July 7, 2005 through 2013. We sometimes found it difficult to pin down details regarding the history of the powerplay. Some of our information was obtained from the following web sources:

- [http://news.bbc.co.uk/sport2/hi/cricket/rules\\_and\\_equipment/4180026.stm](http://news.bbc.co.uk/sport2/hi/cricket/rules_and_equipment/4180026.stm)
- <http://voices.yahoo.com/cricket-power-play-rules-one-day-internationals-4720834.html>
- <http://www.espncricinfo.com/natwestchallenge/content/story/213010.html>
- <http://www.itonlycricket.com/entry/106/>

**A: July 7/2005–September 6/2008** – We have 239 observed matches where the match identifiers range from 2259 to 2762. During this period, there were three blocks of powerplays which imposed stricter fielding restrictions compared to the rest of the match. The first 10 overs of the innings imposed fielding restrictions which allowed only two fielders outside the 30-yard circle and two fielders within 15 yards of the on-strike batsman. This was known as the mandatory powerplay. The mandatory powerplay was followed by a five-over block known as powerplay 2 and a subsequent five-over block known as powerplay 3. The initiation of the two non-fixed powerplays were determined at the discretion of the bowling team. In both powerplays, the fielding restrictions allowed only three fielders outside of the 30-yard circle. If no powerplay had been initiated, then overs 41–50 automatically became powerplays. If only one powerplay had been initiated, then overs 46–50 automatically became powerplay 2.

**B: October 9/2008–September 20/2011** – We have 224 observed matches where the match identifiers range from 2763 to 3197. Rule B is the same as Rule A except that the start of one of the discretionary powerplays became the decision of the batting team. Hence the nomenclature for the two discretionary powerplays became the “bowling powerplay” and the “batting powerplay” accordingly. Although it is technically possible for the batting powerplay to precede the bowling powerplay, this did not occur in any of the 224 matches. The rationale for the introduction of Rule B was based on the observation that under Rule A, the bowling team often employed powerplays 2 and 3 as soon as possible (i.e. in overs 11–15 and 16–20, respectively). With the decision to start one of the powerplays given to the batting team, the hope was to spread the powerplays throughout the innings.

**C: October 13/2011–September 5/2012** – We have 51 observed matches where the match identifiers range from 3198 to 3304. Rule C is similar to Rule B except that the bowling and batting powerplays were not allowed to take place neither during overs 11–14 nor during overs 41–50.

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