Wicket loss and risk taking during the 2011 and 2015 Cricket World Cups

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Abstract

The purpose of the current investigation was to determine whether there is an optimal strategy in one-day international cricket and whether there is an even distribution of wickets during a 50 over innings. The investigation included 92 matches from the 2011 and 2015 Cricket World Cups. An initial study used required run rate at the start of overs within second innings as an indication of strategy required to reach the target number of runs. This suggested that teams played optimally when 8 to 10 runs were required per over. The second study revealed that batting teams within the both innings lost fewer wickets and scored fewer runs during the first half of innings than during the second half. Despite winning teams within matches losing wickets significantly later than losing teams, this pattern of an increasing run rate and an increasing rate of wicket loss was observed for both winning and losing teams. Teams are not awarded any additional runs for having wickets remaining at the end of the 50 overs. International teams may be more successful if they are prepared to risk losing more wickets in the first half of innings in an attempt to score runs.

Key words: run rate, one-day cricket.

1. Introduction

Many sports require players and teams to devise strategies prior to competition (Hibbs and O'Donoghue, 2013) and make tactical decisions during play (Fuller and Alderson, 1990). The purposes of practical performance analysis include tactical evaluation (Hughes, 1998) which can help players and teams to optimise their own playing styles as well as understand the strategies and tactics adopted by opponents. The study of successful tactics in sport has also received recent attention within academic research (Costa et al., 2011; Castellano et al., 2013; Tirp et al., 2014).

Tactical decision making within games requires performers to choose between options that are available to them during the current situation. Each option has advantages and disadvantages and performers use available information (Williams and Davids, 1998) and perceived probabilities of different outcomes to select an option in a given situation (Singer and Janelle, 1999). Often the tactics associated with the greatest opportunities for success are also those with the greatest risk (Hibbs and O'Donoghue, 2013). By contrast, 'playing safe' usually limits the opportunity for success (Herbert, 1991). Tactics can also be influenced by the current game state, where performers have to take risks in order to have any chance of winning. Game state is a combination of current match score, time-remaining, numerical advantage and the success of tactics used so far (Mitchell-Taverner, 2005).

The current paper considers tactical decision making in one day cricket with respect to game state. Each team contesting a one day cricket match has an innings of 50 overs of 6 legitimate balls each (300 legitimate balls per team). As one team has a batting innings, the other team is fielding which involves bowling. There is a short time between bowls (about 30s) and between overs (about 1 minute) for considering tactics more carefully than is possible in many other sports (Brooker, 2010). The batting team needs to make enough runs to win the match. A batsman can make 4 runs if a shot reaches the boundary or 6 runs if the shot crosses the boundary without bouncing on the cricket field. However, attempting to hit a 4 or a 6 does come with an increased risk of the batsman being dismissed (Woolmer et al., 2008, p.387). The risk is increased further if the fielding team are aware that the batting team need to aim for 4s and 6s and can, therefore, predict the types of shots the batting team will attempt. Where a batsman is dismissed, it is called a "wicket". There are lower risk shots where a batsman can elect to attempt one or two runs or not attempt to run at all. There are 11 batsmen and two must be batting at all times during the innings. Therefore, once 10 batsmen have been dismissed the innings is completed. It is, therefore, possible for innings to be completed before 50 overs are played where 10 wickets have been taken. It is also possible for all 50 overs to be played with fewer than 10 wickets lost. Individual players have been assessed using run rates and wicket statistics (Kantor, 2007). Batsmen have been assessed using runs scored per 100 balls and risk of dismissal per 100 balls. Bowlers, on the other hand have been evaluated using wickets per 100 deliveries and "economy rate" which is the number of runs opposing batsmen score per over. These individual player statistics that pool performances within tournaments allow useful comparisons between players. However, if individual match performances of players were considered separately it would allow relationships between risk and opportunity to be investigated using the same set of players. This would avoid results being influenced by inter-individual differences.

Figure 1 is a conceptual model of the factors influencing tactics during the second innings of a one day cricket match. The number of runs scored by the team that batted during the first innings is the target number of runs. This needs to be exceeded by the team that is batting during the second innings if they are to win. The fielding team in the second innings needs to prevent the batting team from scoring the required number of runs. There is a direct interaction between the performances of the batting and fielding teams. Interacting Performances Theory recognises such direct opposition effects on the tactics adopted by teams and individuals as well as the effectiveness with which tactics are applied (O'Donoghue, 2009). An example of such direct opposition effect in cricket is fielding positions being based on probability of striking zones (Woolmer et al., 2008, p.372). Cricket presents an aspect of sports performance that has not been considered within Interacting Performances Theory. This is the idea that play can be controlled more by the fielding team or the batting team in different situations. For example, spin bowlers can set traps for batsmen over a series of deliveries (Woolmer et al., 2008, p.392). Where the batsmen at the crease are dictating the innings, bowlers can vary the pace, line or angle of deliveries to disrupt the batsmen (Woolmer et al., 2008, p.403-5). This can lead to a greater level of control by the fielding team.

At any point in the second innings, the number of runs required is the difference between the opposition's total plus one and the runs made so far within the innings. The number of overs remaining and the runs required determine the necessary run rate needed to achieve the target. In attempting to achieve the target, the number of batsmen remaining also needs to be considered. The batting team needs to avoid losing 10 wickets before it has reached the opposition's total. This can lead to differing tactics with respect to risks taken where differing numbers of batsmen remain in situations when the same run rate is required.

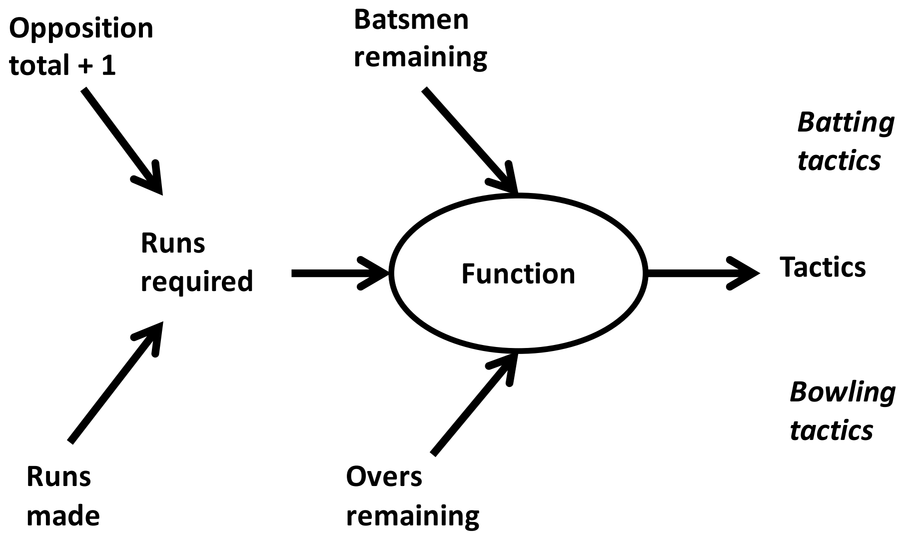

Figure 1. Factors influencing tactics in the second innings of a one day cricket match.

Understanding the risks associated with raised run rates has allowed predictive models of limited overs cricket matches to be developed. One such model is WASP (Winning and Score Predictor) that is based on average team performance for teams in the World's top 8 teams (https://en.wikipedia.org/wiki/WASP_(cricket_calculation_tool), accessed 8th December 2015). WASP has been used by cricket broadcasters to predict the total to be achieved by the team batting first and the probability of the team batting second winning the match given the current game state within the second innings (http://www.blackcaps.co.nz/news-items/archive/whats-wasp-all-about, accessed 8th December 2015). WASP is a useful infotainment system for cricket audiences that has been extended to describe what must happened in the next two overs to bring a match back to as state where each team has an equal chance of winning (http://offsettingbehaviour.blogspot.in/2013/11/more-cricket-return-of-wasp.html, accessed 8th December 2015). However, the original research that led to WASP was to determine the risks involved in increasing run rates when aiming for higher innings totals (Brooker, 2010).

In one day cricket, teams are not awarded any additional runs for having wickets remaining at the end of their innings. A strategy that avoids the loss of wickets may be too safe and will be at the expense of scoring runs. A strategy that aims for a high run rate with a relatively large percentage of 4s and 6s being scored may risk losing all 10 wickets too quickly to achieve the required total. Therefore, one might expect batting teams to adopt an optimal strategy risking the loss of 1 wicket every 5 overs in order to maximise the number of runs made during 50 overs. The current investigation consists of two studies; one to examine whether there may be an optimal strategy that maximises the runs made in an innings and one to compare the pattern of wicket losses with an expected pattern. Both studies use data from the 2011 and 2015 Cricket World Cups. There is a wealth of data recorded during cricket matches that has been under-utilised in research (Woolmer et al., 2008, p.446); one-day cricket is not an exception to this. The purpose of the first study was to compare the wickets lost and runs made in overs where different run rates are required to reach the target set. The purpose of the second study was to compare the loss of wickets with an expected pattern assuming a probability of 1 / 30 of losing a wicket on any ball. Such a strategy would be expected to see 10 wickets lost in 300 balls (a single innings of 50 overs).

2. Methods

2.1. Data sources

The number of runs made and the number of wickets lost by batting teams in each over of each match were accessed from internet data from the 2011 Cricket World Cup (http://www.espncricinfo.com/icc-cricket-world-cup-2011, accessed 14th April 2014) and the 2015 Cricket World Cup (http://www.espncricinfo.com/icc-cricket-world-cup-2015, accessed 29th March 2015). The data for the two semi-finals and two pool matches from the 2011 tournament were compared with "fall of wicket" information provided by an alternative source (http://en.wikipedia.org/wiki/2011_Cricket_World_Cup, accessed 10th August 2014) and found to be in complete agreement.

2.2. Research Design

There were 49 matches in each of the 2011 and 2015 Cricket World Cups but 6 were excluded from the study because they were abandoned or the first innings had been stopped before 50 overs when the batting team still had wickets left. Therefore, the total volume of data included in the study was 92 one day international matches. The investigation consisted of two studies. Firstly, batting performance in the second innings was analysed to determine if the required run rate had any influence on runs made and wickets lost. In the absence of any knowledge of teams' decisions about tactics, it was assumed that the teams batting in the second innings would adopt strategies aimed at achieving the target number of runs. The opportunity and risk of the strategies were represented by the runs made and wickets lost within overs. These were compared between overs where different run rates were required to reach the target set in the first innings. The second study compared the wickets in the first and second innings with an expected performance assuming the teams were willing to use all 10 wickets to maximise their score.

2.3. Study 1: Effect of required run rate

Individual overs within the second innings were used as the units of analysis within the first study. There were 3737 overs within the second innings of the 92 matches included in the current research. The required number of runs for the team batting in the second innings to win, R, was set at one greater than the target achieved by the team that batted in the first innings. At the beginning of the V^{th} over, the number of overs remaining was 51 – V and the number of runs still needed, N, was given by equation (1) where r_i is the number of runs scored in the i^{th} over.

$$N = R - \sum_{i=1}^{i=V-1} r_i \quad (1)$$

This means that the required run rate at the start of the V^{th} over is N / (51 – V). The overs were classified by whether they were powerplay overs or not as well as by the required run rate. During powerplays, restrictions on the number of fielders that can be positioned outside the 30 yard circle are applied to the bowling team. Powerplays were introduced in one-day international cricket in 2005 and powerplay rules have evolved since then with rule changes in 2008, 2011, 2012 and 2015. During the 2011 and 2015 Cricket World Cups there were powerplays covering the first 10 overs of each innings. During this powerplay, bowling teams were only permitted 2 fielders outside the 30 yard circle. There were 2 further powerplays of 5 overs each chosen by the fielding team in the 2011 Cricket World Cup where the bowling team was restricted to having 3 fielders outside the 30 yard circle. The timing of one of these powerplays was chosen by the batting team and the timing of the other was chosen by the bowling team. In the 2015 Cricket World Cup, the number of additional 5 over powerplays was reduced from 2 to 1 chosen by the batting side and to be taken between the 11^{th} and 40^{th} overs inclusive.

The required run rates during each of the 3737 overs were classified into the following 8 types which gave a crude indication of the level of risk that might be required:

- Fewer than 2 runs per over
- 2 to less than 4 runs per over
- 4 to less than 6 runs per over
- 6 to less than 8 runs per over
- 8 to less than 10 runs per over
- 10 to less than 12 runs per over
- 12 to less than 14 runs per over
- 14 or more per over

The mean and standard deviation were determined for the observed runs made and wickets lost within each class of over during the second innings of matches. These data were used to calculate an expected number of overs (maximum of 50) and an expected number of runs for an innings based on the observed performance.

2.4. Study 2: Comparison of wickets lost

The purpose of the second study was to compare the rate of wicket loss observed within the first innings and second innings of the 92 matches with an expected loss rate of one wicket every 5 overs. The over in which each wicket was taken was determined for each innings of each of the 92 matches included in the study. The median, lower and upper quartiles for the overs in which wickets were taken were determined for first and second innings performances separately.

A Microsoft Excel Spreadsheet was programmed to perform a simulation of 10,000 innings assuming a probability of losing a wicket of 1 / 30 on any ball. The median, lower quartile and upper quartile of the overs where wickets were lost in these 10,000 simulations were determined and compared with the values from the 2011 and 2015 Cricket World Cups. Mann-Whitney U tests were used to contrast the performances of winning and losing teams within the 91 matches that were won by one team or the other. This was done for the teams that batted in the first innings and in the second innings separately.

3. Results

3.1. Study 1: Effect of required run rate

A crude estimation of risk required is the runs needed in remaining overs for second innings batting teams to achieve the target set by the team that batted first. Table 1 shows the runs made and wickets lost when different run rates were required during powerplay and non-powerplay overs. The expected number of runs that could be made in an innings is maximal when the batting team requires between 8 and 10 runs per over during non-powerplay overs and overall. During powerplay 2 overs, the number of runs expected within an over is highest when 2 to 4 runs or 8 to 10 runs are required per over. However, during powerplay 1 and powerplay 3 overs, the expected number of runs that could be made in an innings was maximised when fewer than 2 runs are required per over. The results for powerplays 1 and 3 show the highest run performances when fewer than 2 runs were required per over. These overs were typically played by the better teams within the tournaments who had restricted their opponent's total score during the first innings through effective fielding. This is especially true of powerplay 1 which is typically played in the first 10 overs. The non-powerplay results suggest that there may be an optimal strategy based on aiming for 8 to 10 runs per over that maximises the expected runs that can be made in an innings.

Table 1. Runs made and wickets lost during second innings (mean±SD).

Runs required per over	N	Runs made per over	Wickets lost per over	expected overs	expected runs per innings
Non-powerplay					
Fewer than 2	168	5.28±3.94	0.131±0.372	50.0	264.0

2 to less than 4	267	4.70±3.27	0.146±0.374	50.0	235.0
4 to less than 6	499	4.63±3.05	0.138±0.363	50.0	231.4
6 to less than 8	665	5.12±3.19	0.144±0.368	50.0	255.9
8 to less than 10	399	5.41±3.72	0.173±0.428	50.0	270.3
10 to less than 12	140	5.65±3.56	0.257±0.514	38.9	219.7
12 to less than 14	69	4.93±3.83	0.391±0.574	25.6	125.9
14 plus	108	4.85±4.16	0.472±0.618	21.2	102.7
All	2315	5.04±3.43	0.177±0.418	50.0	252.0
Powerplay 1					
Fewer than 2	49	6.33±5.36	0.163±0.426	50.0	316.3
2 to less than 4	158	5.86±4.45	0.133±0.376	50.0	293.0
4 to less than 6	331	4.85±3.65	0.127±0.342	50.0	242.7
6 to less than 8	343	4.76±3.88	0.184±0.451	50.0	238.2
8 to less than 10	36	5.19±4.30	0.250±0.439	40.0	207.8
All	917	5.09±4.03	0.156±0.400	50.0	254.3
Powerplay 2					
Fewer than 2	23	4.83±3.01	0.130±0.344	50.0	241.3
2 to less than 4	25	6.52±3.45	0.280±0.542	35.7	232.9
4 to less than 6	32	6.31±3.89	0.188±0.397	50.0	315.6
6 to less than 8	43	7.12±4.35	0.326±0.606	30.7	218.6
8 to less than 10	58	6.48±4.30	0.207±0.409	48.3	313.3
10 to less than 12	49	4.86±3.72	0.306±0.466	32.7	158.7
12 to less than 14	17	4.71±3.00	0.294±0.470	34.0	160.0
14 plus	41	5.68±3.86	0.341±0.530	29.3	166.4
All	288	5.93±3.92	0.264±0.479	37.9	224.9
Powerplay 3 (2011 matches only)					
Fewer than 2	11	5.82±5.06	0.000±0.000	50.0	290.9
2 to less than 4	35	5.80±3.47	0.086±0.284	50.0	290.0
4 to less than 6	91	4.86±3.32	0.110±0.314	50.0	242.9
6 to less than 8	70	4.07±3.12	0.100±0.302	50.0	203.6
8 plus	10	4.20±2.94	0.200±0.422	44.0	192.0
All	217	4.77±3.40	0.101±0.303	50.0	238.7
Overall					
Fewer than 2	251	5.47±4.23	0.131±0.372	50.0	273.3
2 to less than 4	485	5.25±3.76	0.144±0.380	50.0	262.6
4 to less than 6	953	4.78±3.34	0.133±0.352	50.0	239.2
6 to less than 8	1121	5.02±3.49	0.161±0.404	50.0	251.1
8 to less than 10	501	5.50±3.83	0.182±0.425	50.0	275.0
10 to less than 12	191	5.42±3.61	0.272±0.502	36.7	199.0
12 to less than 14	86	4.88±3.66	0.372±0.554	26.9	131.3
14 plus	149	5.08±4.08	0.436±0.596	22.9	116.5
All	3737	5.10±3.63	0.174±0.414	50.0	255.2

3.2. Study 2: Comparison of wickets lost

Table 2 compares the performances in the 92 matches included in the study with expected performances generated by simulation of innings assuming a probability of losing a wicket of 1 / 30 in any ball. The median over where any wicket was lost occurred later than expected for both the team batting in the first innings and the second innings. The number of matches where particular wickets were not taken is also shown in Table 2. The expected value for the number of simulated innings where any wicket was expressed as percentages to allow comparison with the actual matches included in the study. For example, the expected 46.2% where the tenth wicket is not taken was the percentage of the 10,000 simulated innings where this was the case.

Table 2. Overs where wickets were lost in the 2011 Cricket World Cup compared with an expected pattern assuming a probability of a wicket being lost of 1 / 30 in any ball (lower quartile : median : upper quartile).

Wkt	Expected		1st Innings		2nd Innings	
	Over of dismissal (LQ:**Median**:UQ)	% Matches where the wicket was not taken	Over of dismissal (LQ:**Median**:UQ)	% Matches where the wicket was not taken	Over of dismissal (LQ:**Median**:UQ)	% Matches where the wicket was not taken
1	2 : **4** : 7	0.0	3 : **5** : 9.25	0.0	2 : **5.5** : 8	4.3
2	5 : **9** : 14	0.0	8 : **12** : 22	1.1	7 : **10** : 18	9.8
3	9 : **14** : 20	0.2	16.25 : **26.5** : 33	2.2	11 : **18** : 27	12.0
4	13 : **18** : 25	0.9	25.25 : **33.5** : 41.75	2.2	18 : **25** : 33.5	18.5
5	17 : **23** : 30	2.4	32.5 : **41** : 45.5	5.4	22 : **29.5** : 38	28.3
6	21 : **27** : 34	5.8	36 : **45** : 48	7.6	25 : **34** : 42	33.7
7	24 : **31** : 37	12.2	39 : **45.5** : 49	26.1	29.75 : **37** : 43	39.1
8	28 : **34** : 40	21.5	42 : **44** : 49	40.2	33 : **40** : 44.25	43.5
9	30 : **36** : 41	33.2	43.75 : **46.5** : 49	47.8	36.5 : **42** : 47	47.8
10	32 : **38** : 43	46.2	44 : **47.5** : 50	56.5	37 : **43** : 47	55.4

Table 2 only shows wickets that actually occurred within the World Cup matches and simulated innings. Figures 1 and 2 show the worm charts (cumulative runs plotted against overs within an innings) for the first and second innings excluding the one drawn match. These data represent any remaining wickets as being lost after the 50 overs were completed. An arbitrary value of over 51 was used for these remaining wickets. This meant that the mean over where a wicket was lost could not be meaningfully calculated and the median was used instead. The median team that batted first and won the match only lost 6 wickets during the innings compared with all 10 wickets being lost by the median team that batted first and lost the match. Considering the teams that chose to bat first, the winning team did not lose their first wicket significantly later than the losing team ($p = 0.097$) but lost all of the remaining wickets significantly later than the losing team ($p < 0.001$). The median team that batted second and won the match only lost 4 wickets during the innings compared with all 10 wickets being lost by the median team that batted second and lost the match. The winning teams that batted in the second innings lost each wicket during a significantly later over than the losing teams that batted in the second innings ($p <= 0.007$).

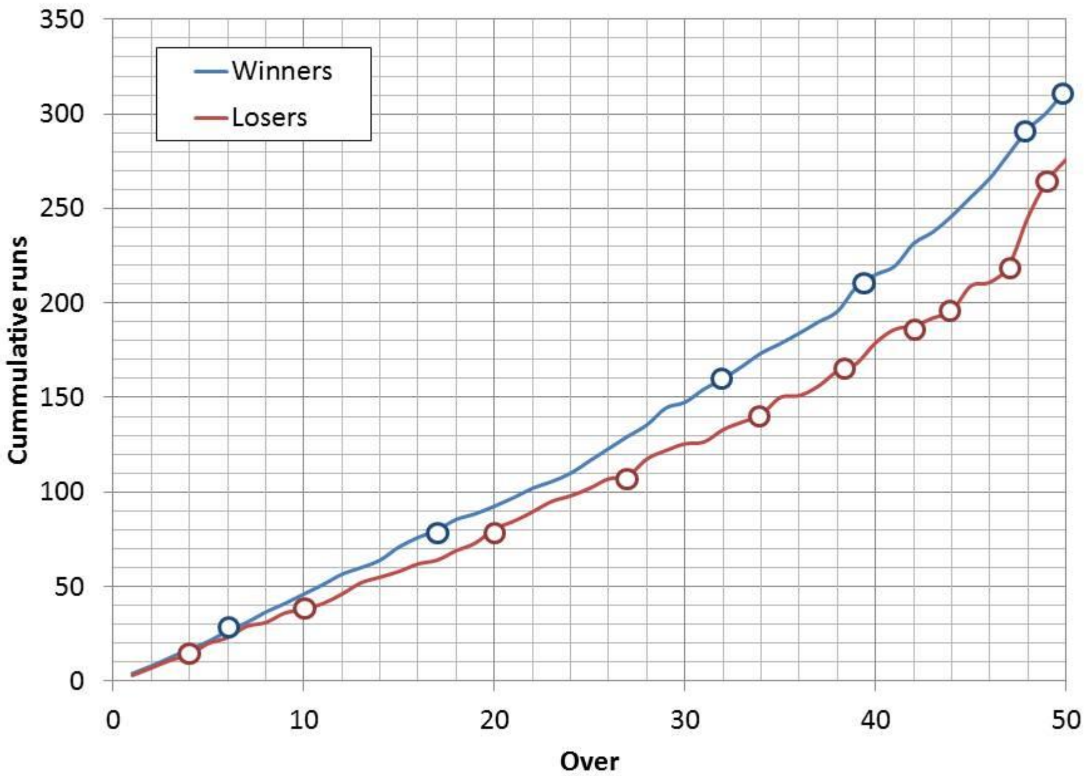

Figure 2. Worm chart for teams batting in first innings (n=92). Dots represent wicket losses, values are medians.

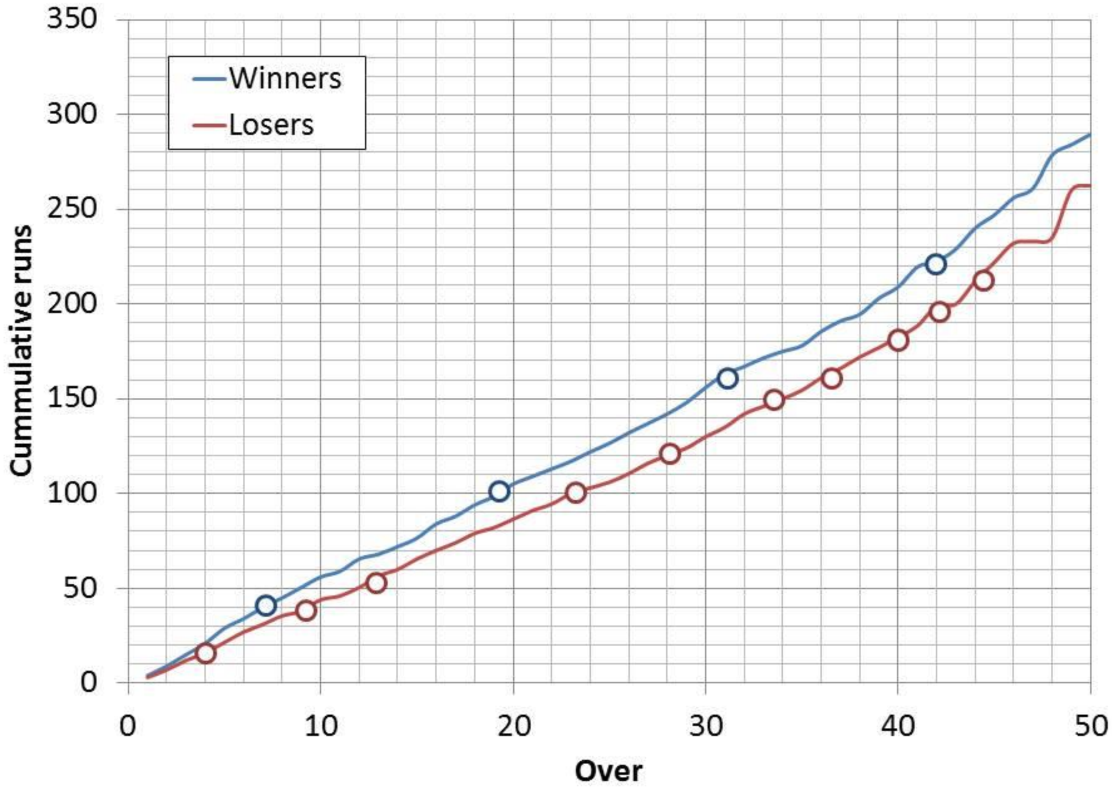

Figure 3. Worm chart for teams batting in second innings (n=92). Dots represent wicket losses, values are medians).

4. Discussion

The results of the first study agree with Brooker's (2010) analysis of international one-day cricket matches that revealed a higher run rate during powerplay overs than during non-powerplay overs. The results of the first study also suggest that a strategy based on aiming for 8.00 to 9.99 runs per over is optimal for maximising runs per innings. Aiming for a lower run rate has the disadvantage that there will only be 50 overs even if the team have wickets left at the end of the innings. Aiming for a higher run rate risks not completing 50 overs due to losing all 10 wickets before the 50th over. A limitation of the first study is that it is not a controlled experiment where batting players have been instructed about the run rate required. However, the results do agree with the view expressed in other research papers that batting strategy in cricket can be optimised (Clarke, 1988; Preston and Thomas, 2000; Brooker, 2010). Former Australian team coach Bob Simpson used the term "controlled aggression" suggesting an optimal way of batting (Pyke and Davis, 2010, p.49). Woolmer et al. (2008, p.390) also suggested an optimal strategy requiring level heads and mature innovation between overs 16 and 40 in one day cricket. However, Woolmer et al. (2008, p.394) also described anything less than 8 to 10 runs per over in the final 10 overs as failure. This does not apply to teams batting in the second innings who will be chasing the set target number of runs.

Brooker (2010) has developed the concepts of a trade-off between run rate and the risk of losing a wicket, cost of a wicket and optimal batting strategy. Aiming for a higher run rate raises the risk of losing a wicket. The cost of a wicket is the difference in expected number of runs that could be made in the remaining balls when the wicket is lost and when it is preserved during the current ball. Brooker's model suggests that a cautious approach by batting teams during early overs of an innings may not be an optimal strategy. There may be a mentality in cricket where players and coaches consider wickets to be more serious than they actually are. For example, Pyke and Davis (2010, p.38) wrote "a batting error can produce the most severe outcomes; it is akin to a soccer player being sent off the field straight after kick off". The results of the current investigation suggest that teams could afford to lose some more wickets in an attempt to score a higher number of runs. An alternative explanation for the lack of wickets being lost early within innings is the priority for fielding teams to restrict the batsmen's opportunities to make boundaries rather than taking wickets (Pyke and Davis, 2010, p.121). Indeed, conditions in the early stages of an innings are considered to be relatively favourable to the bowling team due to the new ball being harder and batsmen not being accustomed to the bounce of the pitch and the pace of the ball (Woolmer et al., 2008, p.387). Another example of the importance of wickets potentially being overstated was when Woolmer at al. (2008, p.394) described being bowled out short of the allotted overs as "unforgivable". Woolmer et al. (2008, p.394) also prioritised seeing out an innings over scoring boundaries.

There is a recognition that some shots with opportunities for scoring runs come with a higher risk of dismissal than shots that may be less productive in terms of scoring. Dellor (2010, p.76) described how drives can bring a host of runs but at some risk. The sweep is a shot with the potential to disrupt a bowler's rhythm but which also comes with a higher risk of dismissal (Dellor, 2010, p.87). There is also variation in risk within shots based on how hard they are played (Dellor, 2010, p.85); the ball should not be played too hard as this could result in loss of balance and risk of losing the wicket. By contrast, there are other shots, such as the leg glance, that can be played for an easy run with relatively low risk (Dellor, 2010, p.102). The risks associated with shots are also influenced by the length and width with which the ball is bowled (Pyke and Davis, 2010, p.49).

The strategy adopted should be dictated by the given situation (Dellor, 2010, p.106). The situation is a combination of run rate required, wickets remaining, overs remaining, opposition quality, pitch conditions and environmental factors. Batsmen at the crease need to adjust their batting style as the required run rate changes throughout an innings (Woolmer et al., 2008, p.396). While players can adopt general strategies in the pursuit of run targets, they need to be reactive to the ball played by the bowler (Boycott, 1995, p.135-6; Gower, 1995 p.139; Pyke and Davis, 2010, p.56). An example of this is the hook which can be played as a response to a short ball from a quicker bowler that arrives between chest and head height (Dellor, 2010, p.99). In this situation the batsman still needs to make the decision whether to play the shot or to duck and not play the hook based on perceived risk of dismissal.

The findings of the second study show that teams lose wickets later than expected based on the fact that they have 10 wickets to be used within 300 balls; this applies to teams batting first and second as well as to winning and losing teams within matches. The results agree with the suggestion of Barr et al. (2008) and Brooker (2010) that batting teams should aim to score more runs in the early overs of innings than they did in the 2007 Cricket World Cup. However, the remainder of this discussion discusses the potential explanations for the lower run rate and wickets lost in the first half of innings.

There are some findings in the second study that agree with findings from previous research into World cup Cricket that winning teams score more runs and lose fewer wickets (Petersen et al., 2008a). An explanation for the lower run rates and dismissal rates in the early overs of innings is offered by Geoffrey Boycott (1995, p. 127-34). Boycott described the process of batsmen building an innings using the early overs to familiarise with the bowlers, pitch conditions and general environment and to develop knowledge of the situation. Pitch conditions vary between different countries (Gower, 1995, p.144) which should also be considered by batsmen during the early stages of innings. Batsmen should be concerned with scoring single runs during the early stages of an innings. For example, the leg glance is a low risk shot that can be used to make single runs that is recommended early within innings when facing pace bowlers (Dellor, 2010, p.102). A cautious approach builds a foundation to an innings (Pyke and Davis, 2010, p.56). Boycott recommended being patient, avoiding taking risks during the early balls of an innings, in particular avoiding lofted shots at the start. This may be a common strategy of international batsmen, as Boycott (1995, p. 128) put it; “I have seen very few batsmen in the World that can take an attack apart right from the word go”.

Once a batsman has played himself into an innings, then he can begin to find gaps and look for chances to score more runs (Boycott, 1995, p.136). Some batsmen commencing when the innings is well underway may have to use an attacking style if the required run rate is relatively high. David Gower (1995, p.139-144) recommended clearing the mind of possible dangers, visualising possibilities for scoring and knowing where gaps in the field are. Gower also warned against increasing the tempo too suddenly because the captain of the fielding side may be able to recognise the batsmen’s intentions. The increasing risk of wickets in the latter stages of an innings is associated with a higher run rate being aimed for. Indeed some teams may set themselves up for the last 15 over of the innings where they can score 100-120 runs (Woolmer et al., 2008, p.395). Attacking play can be risky where batsmen are chasing a relatively high target. For example, Dellor (2010, p.87) described risking aerial shots in such situations. Batsmen should avoid playing too aggressively, however. A bowler recognising that a batsman is playing aggressively in the chase for runs can upset the batsman’s footwork by bowling varying length balls (Pyke and Davis, 2010, p.83). On the other hand, there may be situations late within innings where runs are required and sufficient wickets remain to allow high risk batting to be tolerated (Woolmer et al., 2008, p.391).

Defensive batting may be required where the batting team has one or two wickets left but the team also has the ability to reach the target set by the team that batted in the first innings. One consideration for defensive batting is that it is not necessary to hit a ball that is not going to hit the stumps (Boycott, 1995, p. 136). Dellor (2010, p. 61) recommended never playing a defensive shot if the ball is not going to hit the stumps. However, risk of dismissal should be minimised if the batting team has sufficient overs but few wickets left to reach their target (Woolmer et al., 2008, p.394).

While batting can be classified as attacking or defensive in style, there may be a range of styles within these broad types of batting with respect to the risks of losing wickets and opportunities to score runs. For example an intermediate attacking style may involve concentrating on singles but taking opportunities to score four or even six runs. For example Dellor (2010, p.75-6, p. 92) described sacrificing 3 runs to keep the scoreboard moving and to avoid losing a wicket, but punishing any bad balls that might be played. The cautious approach is also evidenced by Woolmer et al.'s (2008, p.396) recommendation that batting teams should aim to have at least 4 wickets left after 35 overs. Even in the last 10 overs, an optimal attacking strategy should be used; Woolmer et al. (2008 p.394) summed up the need for some caution at this stage; "Even the best international teams have been known to waste 40 overs of good hard work, losing their heads and throwing away their advantage in just 45 minutes of frankly stupid cricket". Concentration and communication need to be maintained throughout the innings (Lewis, 1995, p.138). Brooker's (2010) dynamic programming model of one-day cricket suggests that there may be a continuum of strategies where risk of losing wickets increases as batsmen aim to score more runs. Different strategies are optimal in different situations based on runs required, balls remaining and wickets remaining.

A further explanation for the low risk of losing wickets early during innings comes from the use of effective batting partnerships. Fifty plus run batting partnerships have been found to distinguish winning and losing teams in Twenty20 cricket (Petersen, et al., 2008b; Douglas and Tam, 2010; Najdan, 2014). Such partnerships are also important in one day cricket. Where a pair of batsmen play singles, it can disrupt the bowler who will be facing alternate batsmen (Pyke and Davis, 2010, p.40-41). Batsmen can also ask their batting partners for feedback during play (Pyke and Davis, 2010, p.58). This may be done better by experienced batting partners. There are also bowling partnerships where an outswinging bowler is setting up a batter by concentrating on getting the batter on the back foot before a swing bowler bowls one fuller length ball which the batsman might deflect for the wicket keeper to catch (Pyke and Davis, 2010, p.85). An extremely dangerous time is when a wicket has just fallen because a batting partnership will have been broken and bowlers are "pumped up" as a new batsman arrives (Woolmer et al., 2008, p.377).

Partnerships should be considered when deciding on the team's batting order. Batting order produces unique problems in cricket batsmen from the third batsman on have the opportunity to assess the conditions before needing to bat (Pyke and Davis, 2010, p.54). In one-day cricket, there may be a justification for using a "pinch-hitter" (a batsman moved up the order to attack the bowlers with high risk to his own innings aiming for a high run rate). Woolmer et al. (2008, p.397) claimed that this is a successful tactic once every seven times it is attempted. Cricket teams need to be comprised of personnel capable of delivering effective batting and bowling performances. Therefore, optimal team selections will include players of differing batting abilities (Damodaran, 2006;

Bhattacharjee and Hemanta, 2014). The differing batting abilities of players within teams is recognised by research into optimal batting orders (Swartz, 2006). The lower dismissal rate observed in the first 25 overs of an innings may be explained by the use of specialist opening batsmen who may be more capable of dealing with early swinging balls (Boycott, 1995, p. 131). A limitation of the current investigation is that the reductive quantitative approach assumes an average batsman. Different batsmen have differing success and risk levels with the same shots (Dellor, 2010, p.75; Pyke and Davis, 2010, p.84). Similarly, bowlers use different styles and have different abilities that need to be considered by batsmen (Pyke and Davis, 2010, p.53-4). A further limitation is that the current investigation did not control for some of the factors mentioned by Brooker and Hogan (2011); ground size, pitch conditions, weather and the skill of the teams involved in matches.

One final explanation for the run rates and wicket loss pattern observed in World Cup cricket may be environmental factors. These may cause a speeding up of run rates as a pitch might slow down later in an innings (Woolmer et al., 2008, p.377).

The current investigation has examined performance during one-day international cricket using runs and wickets. Future research could investigate more detailed variables about cricket performance to explain the observed run rates and dismissal rates that occur. Areas of performance that could be included are ball line and ball length, fielding positions, field position and shot types selected (Hughes and Bell, 2001). Hughes and Bartlett (2002) proposed performance indicators relating to tactics covering types of balls bowled and shot directions. These areas of performance could also be examined in future research. Other areas of future research include studying women's, domestic and junior cricket performance.

5. References

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