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Fair Calculation in the Rain Interrupted Games

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Abstract

The most frustrating part in cricket is when rain starts and game is interrupted. To declare result ICC has been using Duckworth-Lewis (D/L) method. D\L method is a mathematical model and has been applied over 350 ODI matches. It is based on elgant statistical method and has worked extremely well due to its biases against the team batting second, much criticism has been made against it. To overcome these criticisms a proposal is being made to apply new polynomials curve of (n-1) towards the calculations of the results for an interrupted game.

Keywords: Games, Interruption, Results, Matches, Calculations.

Introduction

The D/L method is used to revise targets in limited-overs matches when one or both of the two sides competing have had their innings shortened after the match has started. It was only the fact that several other methods were tried and yielded disastrous results that allowed D/L to be given proper consideration. Such interruptions usually alter the balance of the run-scoring resources available to each side and the method corrects this imbalance. The D/L method is used to revise targets in limited-overs matches when one or both of the two sides competing have had their innings shortened after the match has started. Such interruptions usually alter the balance of the run-scoring resources available to each side and the method corrects this imbalance. Frank Duckworth and Tony Lewis started studying the problem and published a paper in the Journal of Operational Research Society.[1] In 1998, this method was first used in international cricket in the second game of the 1996-97 England vs Zimbabwe. This method was formally accepted by ICC in 2001 and is being used in all the international one day game since. Nevertheless, after eleven years, most people involved in the game now accept that the method has stood the test of time, and even if they are unable to understand the mathematical basis they accept that it works - and works well.[2] Thus the D/L method can be regarded as a case study in how a mathematical approach was imposed upon a non-mathematical audience. The widening appreciation of the important contribution it has made led to increasing awareness of the value of the mathematical sciences in areas far removed from the classroom, lecture theatre or science laboratory.[3]

[1] FC Duckworth and AJ Lewis, "A fair method for resetting the target in interrupted one-day cricket matches", *Journal of the Operational Research Society* 49, (1998), 220-227.

[2] Frank Duckworth, "The Duckworth/Lewis method: an exercise in Maths, Stats, OR and communications" in *Journal of International Operational Research*, 8, (August - October 2008), 3.

[3] *Ibid.*

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The model

The model [1] is the simple two factor exponential relationship:

$$Z(u,w) = Zo\ F(w)\ [1 - \exp\{ - bu/F(w)\}]$$

where $Z(u,w)$ is the average further number of runs expected to be made when there are u overs remaining and w wickets down. $ZoF(w)$ is the asymptotic value of further runs expected with w wickets down as u tends to infinity, F(0) being set to unity. The parameters, *b, Zo* and the nine values of $F(w)$ were estimated from an analysis of a one-day database.

To turn the formula into something fit for consumption, the ratio $Z(u,w)/Z(50,0)$ was calculated for all combinations of 300 values of balls remaining (six balls per over) and ten values of wickets down. These were multiplied by 100 and rounded to one decimal place, thus creating a 'Ready'. Reckoner' of resource percentages from which all target revisions could be calculated. The procedure, in short, was that every time overs were lost, you used the table to read off the resource percentage remaining when play was suspended and then the resource percentage remaining when play was restarted. Finally the resource percentage lost due to the stoppage in play. You do this for each stoppage and so obtain the total resources available to each side for their innings. Team 2's revised target is then obtained by scaling Team 1's final score according to the resources possessed by the two sides. (A slightly different adjustment used to be made, for very good reasons which will not be discussed here, when Team 2 had more resources than Team 1 and so had to be set an enhanced target.) At the time of introduction of the method, computers couldn't be relied upon in order to be present in every scoring box in the world and it was for this reason that a single formula was used giving average resources, this being necessary for the method to be able to be implemented with a single table of resources. The method thus had to rely on the assumption that average performance was proportional to the mean, irrespective of the actual score. In 95 per cent of matches, this was a good enough assumption, but in the other 5 percent, i.e. when very high scores were involved, the simple approach started to break down and consequently targets could be less equitable to the two sides.

To overcome the problem, an upgraded formula was proposed [2]:

$$Z(u,0,?) = ZoF(w)\ ?nF(w){+}1\ \{1 - \exp(-bu/[?nF(w)F(w)])\}$$

The additional parameter, ?, had to be determined for every Team 1 innings, allowing for any stoppages in that innings, and hence it had been found by a numerical method and this could only be done by computer.

PRE D\L METHOD

Pre D\L method there have been many methods used.

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In run - rate ratios the difficulty with run rates is that targets are determined by taking the remaining overs into account, whilst ignoring the number of lost wickets.[4] As is well-known, batsmen tend to bat less aggressively and score fewer runs when more wickets have been taken. For example, for a brief period including the 1992 World Cup, the team batting second had its target reduced from the first innings total by n runs. The quantity was determined as the number of runs scored in the first innings in the corresponding number of lost overs that had the least number of runs scored. In 1992 semifinal between South Africa and England, South Africa was chasing 22 runs from 13 balls to win but following the stoppages their target was amended to 21 runs in 1 ball. This approach was immediately recognized as unfair and advantageous to the team batting first. Another short-lived approach was based on a modification of the previous system by further reducing the target by 0.5% for each over lost. This was generally seen as advantageous to the team batting first.[5]

There have been other proposals that have never been implemented. For example, Clarke[6] developed a dynamic programming model where a target could be set such that the probability of winning prior to the interruption is equal to the probability of winning after the interruption. Christos proposed an alternative method based on run rates but where the number of wickets available is reduced proportional to the number of overs made available.[7] Most of these do not take account of the stage of the innings at which the overs are lost or of the number of wickets that have fallen.

The winning team is decided by the higher average number of runs per over that each team has had the opportunity to receive. It is a simple calculation but the method's major problem is that it very frequently alters the balance of the match, usually in favour of the team batting second.

England had scored 45 runs for 3 wickets in 17.3 of an expected 50 overs when a heavy rainstorm led to the deduction of 27 overs from each innings. England thus resumed their innings for a further 5.3 overs and scrambled 43 more runs to reach a score of (S=)88 in the 23 overs. New Zealand's target in 23 overs was 89 using the ARR method. New Zealand won the game easily. It was clearly an unfair target because of the unexpected and drastic reduction in the number of overs England was expecting to receive. Whereas New Zealand knew from the start of their innings that they were to receive only 23 overs and could pace their innings accordingly. England was deprived of 45.3% of their innings resources, hence RI = 54.7%. New Zealand, in 23 out of 50 overs, had R2 = 65.0% of their innings resources avail-able. Since R2 > RI, New Zealand's revised target would have been, from (4c) with G(50) = 225, T=

[4] Cfr. Rianka Bhattacharya, S Paramjit Gill and B Tim Swartz, "Duckworth-Lewis and Twenty20 Cricket" in *Journal of International Operational Research*, 62, (2011), 151-157.

[5] *Ibid.*

[6] SR Clarke, "Dynamic programming in one-day cricket-optimal scoring rates", *Journal of International Operational Research*, 39, (1988), 331-337.

[7] *Ibid.*

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111.18 which is 112 to win. While this is still not a very demanding target, nevertheless it gives England compensation for not knowing that the interruption would occur and yet rewards New Zealand for playing England into a fairly weak position at the interruption. Our target would have been fair to both teams.[8]

Most productive overs (MPO): The target is determined for the overs the team batting second (Team 2) are to receive by totalling the same number of the highest scoring overs of Team 1. The process of determining the target involves substantial bookwork for match officials and the scoring pattern for Team 1 is a criterion in deciding the winner. We believe that it is only Team l's total that should be used in setting the target and not the way by which it was obtained. The method strongly tends to favour Team 1.

Discounted Most Productive Overs (DMPO): The total from the most productive overs is discounted by 0.5% for each over lost. This reduces slightly the advantage MPO gives to Team 1 but it still has the same intrinsic weaknesses of that method.

Parabola (PARAB): This method calculates a table of 'norms' y, (reproduced in Table 1) for overs of an inning, x, using the parabola y = 7.46x - O.059x2 to the model. Rather inappropriately since it has a turning point (at about 63 overs, the 'diminishing returns' nature of the relationship between average total runs scored and total number of overs available. The method is an improvement upon ARR but takes no account of the stage of the innings at which the overs are lost or of the number of wickets that have fallen. This is an adaptation of the PARAB method. Each of the norms has been converted into a percentage.

India had scored (S=) 226 for 8 wickets in 47.1 out of 50 overs when rain interrupted lay. Their innings were terminated and Pakistan was given a revised target of 186 in 33 overs based on the PARAB method. Pakistan won with overs to spare. The unfairness in this target is that India was unexpectedly deprived of 2.5 overs right at the end of their innings whereas Pakistan knew in advance that only 33 overs would be received. In contrast our method provides a fair target in the following way. India's deprivation of 2.5 overs represents a loss of 8.1% of their innings resources. Thus, India's 226 was a score obtained from RI = 91.9% of their resources. With 33 overs to bat Pakistan have R2 = 81.5% of their innings resources available. Since R2 < R, Pakistan's revised target score would have been, from (4a), T = 200.42, which is 201 to win and a much fairer target for Pakistan to chase.[9]

Clark Curves (CLARK): This method, fully described on the Internet, attempts to correct for the limitations of the PARAB method. It defines six types of stoppage, three for each innings, for stoppages occurring before the inning commences, during

[8] England vs New Zealand, World Series Cup, Perth, Australia, 1983, www.cricinfo.com, (accessed on 20/10/2013).

[9] India vs Pakistan, Singer Cup, Singapore, April 1996, www.cricinfo.com, (accessed on 20/10/2013).

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the innings, or to terminate the innings. It applies different rules for each type of stop-page some of which, but not all, allow for wickets which have fallen. There are discontinuities between the revised target scores at the meeting points of two adjacent types of stoppage.

The D/L (Duckworth/Lewis) method of adjusting target scores in interrupted one-day cricket matches

Table of resource percentages remaining - over by over

2002 update

Overs left 50 to 0

overs left	wickets lost 0	1	2	3	4	5	6	7	8	9	overs left
50	100.0	93.4	85.1	74.9	62.7	49.0	34.9	22.0	11.9	4.7	50
49	99.1	92.6	84.5	74.4	62.5	48.9	34.9	22.0	11.9	4.7	49
48	98.1	91.7	83.8	74.0	62.2	48.8	34.9	22.0	11.9	4.7	48
47	97.1	90.9	83.2	73.5	61.9	48.6	34.9	22.0	11.9	4.7	47
46	96.1	90.0	82.5	73.0	61.6	48.5	34.8	22.0	11.9	4.7	46
45	95.0	89.1	81.8	72.5	61.3	48.4	34.8	22.0	11.9	4.7	45
44	93.9	88.2	81.0	72.0	61.0	48.3	34.8	22.0	11.9	4.7	44
43	92.8	87.3	80.3	71.4	60.7	48.1	34.7	22.0	11.9	4.7	43
42	91.7	86.3	79.5	70.9	60.3	47.9	34.7	22.0	11.9	4.7	42
41	90.5	85.3	78.7	70.3	59.9	47.8	34.6	22.0	11.9	4.7	41
40	89.3	84.2	77.8	69.6	59.5	47.6	34.6	22.0	11.9	4.7	40
39	88.0	83.1	76.9	69.0	59.1	47.4	34.5	22.0	11.9	4.7	39
38	86.7	82.0	76.0	68.3	58.7	47.1	34.5	21.9	11.9	4.7	38
37	85.4	80.9	75.0	67.6	58.2	46.9	34.4	21.9	11.9	4.7	37
36	84.1	79.7	74.1	66.8	57.7	46.6	34.3	21.9	11.9	4.7	36
35	82.7	78.5	73.0	66.0	57.2	46.4	34.2	21.9	11.9	4.7	35
34	81.3	77.2	72.0	65.2	56.6	46.1	34.1	21.9	11.9	4.7	34
33	79.8	75.9	70.9	64.4	56.0	45.8	34.0	21.9	11.9	4.7	33
32	78.3	74.6	69.7	63.5	55.4	45.4	33.9	21.9	11.9	4.7	32
31	76.7	73.2	68.6	62.5	54.8	45.1	33.7	21.9	11.9	4.7	31
30	75.1	71.8	67.3	61.6	54.1	44.7	33.6	21.8	11.9	4.7	30
29	73.5	70.3	66.1	60.5	53.4	44.2	33.4	21.8	11.9	4.7	29
28	71.8	68.8	64.8	59.5	52.6	43.8	33.2	21.8	11.9	4.7	28
27	70.1	67.2	63.4	58.4	51.8	43.3	33.0	21.7	11.9	4.7	27
26	68.3	65.6	62.0	57.2	50.9	42.8	32.8	21.7	11.9	4.7	26
25	66.5	63.9	60.5	56.0	50.0	42.2	32.6	21.6	11.9	4.7	25
24	64.6	62.2	59.0	54.7	49.0	41.6	32.3	21.6	11.9	4.7	24
23	62.7	60.4	57.4	53.4	48.0	40.9	32.0	21.5	11.9	4.7	23
22	60.7	58.6	55.8	52.0	47.0	40.2	31.6	21.4	11.9	4.7	22
21	58.7	56.7	54.1	50.6	45.8	39.4	31.2	21.3	11.9	4.7	21
20	56.6	54.8	52.4	49.1	44.6	38.6	30.8	21.2	11.9	4.7	20
19	54.4	52.8	50.5	47.5	43.4	37.7	30.3	21.1	11.9	4.7	19
18	52.2	50.7	48.6	45.9	42.0	36.8	29.8	20.9	11.9	4.7	18
17	49.9	48.5	46.7	44.1	40.6	35.8	29.2	20.7	11.9	4.7	17
16	47.6	46.3	44.7	42.3	39.1	34.7	28.5	20.5	11.8	4.7	16
15	45.2	44.1	42.6	40.5	37.6	33.5	27.8	20.2	11.8	4.7	15
14	42.7	41.7	40.4	38.5	35.9	32.2	27.0	19.9	11.8	4.7	14
13	40.2	39.3	38.1	36.5	34.2	30.8	26.1	19.5	11.7	4.7	13
12	37.6	36.8	35.8	34.3	32.3	29.4	25.1	19.0	11.6	4.7	12
11	34.9	34.2	33.4	32.1	30.4	27.8	24.0	18.5	11.5	4.7	11
10	32.1	31.6	30.8	29.8	28.3	26.1	22.8	17.9	11.4	4.7	10
9	29.3	28.9	28.2	27.4	26.1	24.2	21.4	17.1	11.2	4.7	9
8	26.4	26.0	25.5	24.8	23.8	22.3	19.9	16.2	10.9	4.7	8
7	23.4	23.1	22.7	22.2	21.4	20.1	18.2	15.2	10.5	4.7	7
6	20.3	20.1	19.8	19.4	18.8	17.8	16.4	13.9	10.1	4.6	6
5	17.2	17.0	16.8	16.5	16.1	15.4	14.3	12.5	9.4	4.6	5
4	13.9	13.8	13.7	13.5	13.2	12.7	12.0	10.7	8.4	4.5	4
3	10.6	10.5	10.4	10.3	10.2	9.9	9.5	8.7	7.2	4.2	3
2	7.2	7.1	7.1	7.0	7.0	6.8	6.6	6.2	5.5	3.7	2
1	3.6	3.6	3.6	3.6	3.6	3.5	3.5	3.4	3.2	2.5	1
0	0	0	0	0	0	0	0	0	0	0	0
overs left	0	1	2	3	4	5	6	7	8	9	overs left

wickets lost

Overs left 50 to 0

How D\L method works

The D/L method works using the notion that teams have two resources with which to make as many runs as they can - these are the number of overs they have still to receive and the number of wickets they have in hand. From any stage in their innings, their further run-scoring capability depends on both these two resources in combination. The single table gives the percentage of these combined resources that remain for any number of overs left and wickets lost. An extract of the over-by-over is given in the table.

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Reading the table

The single table applies to all lengths of one-day matches from 50 overs-per-side downwards. Since 50 overs-per-side matches are by far the most common, the resources listed in the table are expressed as percentages of those available at the start of a 50 over innings. Thus when there are 50 overs still to be received and no wickets have been lost, the resource percentage available is 100%. 40 over innings start with a resource percentage of 90.3% compared to a 50 over innings. In order to determine the correct resource percentage it is emphasised that irrespetive of the stage of innings on the batting side, any number of overs left must be identified. This number of overs left, in conjunction with the number of wickets lost, is then used to read the resource percentage remaining from the table.

For example : A team have lost five wickets after receiving 25 of their 50 overs when rain stops play. At this point using the table produced by D\L method the team's remaining resources are valued at 42.4 %. If out of 15 overs ten overs are lost due to weather, the innings will be completed after only 10 overs. Then looking at the table 26.1% of the resources is left to compensate for the lost over.

42.2 - 26.1= 16.1

If the team had been chasing total of 250 run then the new target is calculated in the following way: Resources available at the start =100%, Resources lost=16.1%, Resources available after rain interruption=83.9%. Then the target will be 250 X 83.9%=209.75= 210(R.O)

Criticism to D/ L method

The problem with the Duckworth-Lewis method is that it does not take into account the quality of players left with each team. In D\L method wicket is heavily weighted resource than overs.[10] If D\L method is used, a winning strategy would be not to lose wicket. Next criticism is that it does not take into the account the field restrictions.

New Method

As an improvement over the D|L method if we record 100 recent cricket games and study the game in a graph form and use a polynomial of degree (n-1) of curve fitting technique (Y=Ax2+ Bx + C) the result would become accurate. In this process the bias against team batting second would be removed and the criticisms of wicket and field restriction could be eliminated.

The basic principle is that each team in a limited-overs match has two resources available to score runs which are the wickets in hand, and the overs left to play.

[10] Guruprasad Nayak, Udbhav Singh Arnab Bhattacharya, "Predicting Target Scores for Rain Interrupted Cricket Matches" source http://home.iitk.ac.in/ ~gprasadk/CS498.pdf, (accessed on 21-10-13).

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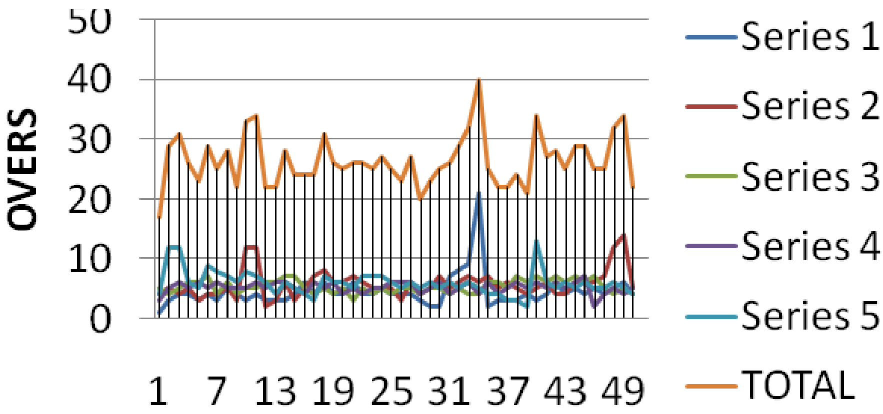
Another criticism is that the D/L method does not account for changes in proportion of the innings for which field restrictions are in place compared to a completed match.



From the above graph one can observe that the displayed mode of calculation performs consistently better compared to D|L method. In this case each team having the resources of remaining wickets and overs-left-to- play are being weighted equally and account taken also for the changes in proportion of the innings for which field restrictions takes place in a match.

Janessa Method

This method is a proposal to overcome the tie in a one day cricket game. It is developed for resolving tie breaker situations in a game of cricket wherein the probability of winning prior to the tie is equal to the probability of winning after the tie. Proposed method is an alternative based on run rates are made proportional to the overs available. In the construction of a new resource table for tie breaker, it is important to consider the scoring patterns. For that reason, I have considered all 5 international one day tie matches from 1990-2013 available on www.cricinfo.com. I have used the following statistical methods to calculate run rate:

i) Mean

ii) Standard Deviation.

iii) Co-efficient Variation

In a match both the teams A and B scores 100 in 50.

OVERS	Team A	Team B
01-10	35	20
11-20	27	15
21-30	20	20
31-40	13	35
41-50	5	10

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TEAM A	TEAM B
MEAN: 18.1 SD: 1.205	MEAN: 48.1 SD: 1.205

CV= (SD/MEAN) X100

CV A: 6.65 CV B=2.59

Since the co efficient of variation for Team A is larger than that of Team B, Team A is considered the winner.

It is designed so that neither team benefits or suffers from the result of the game and so is totally fair to both. It is easy to apply, requires nothing more than a single table of numbers and a pocket calculator, and is capable of dealing with any number of tie at any stage of either or both innings. The method is based on simple model involving a two factor relationship giving the number of runs which was scored in number of overs. Through the examples given, both hypothetical and real, we have shown that our method gives sensible and fair targets in all situations. It is observed that proposed methods perform consistently well.

Conclusion

We have thus for explain the mechanisms of prevailing methods used for resetting target scores in interrupted one-day cricket matches. While each of these methods yield a fair target in some situations, none has proved satisfactory in deriving a fair target under all circumstances. The new method presented give a fair revised target score under all circumstances. Through the examples given, both hypothetical and real, it has been shown that the method gives sensible and fair targets in all situations. However, the new method requires the electronic storage of all relevant information of one day games including runs in each over and the creation of a database.