A fair method for resetting the target in interrupted one-day cricket matches

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A method is described for setting revised target scores for the team batting second when a limited-overs cricket match has been forcibly shortened after it has commenced. It is designed so that neither team benefits or suffers from the shortening of the game and so is totally fair to both. It is easy to apply, requring nothing more than a single table of numbers and a pocket calculator, and is capable of dealing with any number of interruptions at any stage of either or both innings.

The method is based on a simple model involving a two-factor relationship giving the number of runs which can be scored on average in the remainder of an innings as a function of the number of overs remaining and the number of wickets fallen. It is shown how the relationship enables the target score in an interrupted match to be recalculated to reflect the relative run scoring resources available to the two teams, that is overs and wickets in combination. The method was used in several international and domestic one-day competitions and tournaments in 1997.

Keywords: sports; modelling; practice of OR; cricket

Introduction and background

The use of mathematical modelling in sport in general and cricket in particular has been growing in recent years. OR techniques have been used in scheduling cricket fixtures.[1–5] In the game of limited overs cricket, Clarke[6] and Johnston *et al*[7] have used dynamic programming, the former to assist in determining optimal scoring rate strategies and the latter in assessing comparative player performances particularly between batting and bowling. In his paper Clarke[6] suggests that his methodology could be used to assist in setting a fair target in rain interrupted one-day matches but his ideas have not been taken up. It is this problem which is the topic of this paper.

In 'first-class' cricket each side has two innings, each with ten wickets to lose and with no limit on the number of overs that can be bowled. As the time scheduled for the match often expires before the game has finished the most common result is a draw. It was as a natural response to this intrinsic weakness of the first-class game that limited overs, or 'one-day', cricket evolved in the 1960s. In this game, each side has only one innings with a limited number of overs in which to bat, generally either 40, 50 or 60 according to the rules of the competition. As the game is played out to a finish in a single day and often yields exciting finishes, it has proved very popular with the spectators and there can be little doubt that it is here to stay.

But one-day cricket has a major problem. It is intolerant of interruptions due to the weather. In first class cricket a stoppage because of rain or bad light is a natural, though generally unwelcome, part of the game. A one-day match, however, is intended to be finished in a single day and there is usually insufficient spare time when playing conditions are acceptable to make up for the loss of more than a very few overs.

Some competitions schedule extra days to cover the eventuality of the game not being able to be completed on the day planned. But in many cases this is not practicable. As a 'draw' is contrary to the whole purpose of limited-over cricket, and knock-out competitions demand a positive result anyway, rules have had to be introduced to cope with the possibility of the match having to be shortened. If there is a delay to the start, then the number of overs per team is simply reduced equally and equitably for both teams. But if there is an interruption after play has commenced, there are problems.

The difficulties arise because of the nature of the game. The first team batting are set the problem of optimising the total number of runs they can make within the constraints imposed by two limited resources. They have a maximum number of allocated overs, and they have ten wickets which they can lose, of generally decreasing value as they go down the order after the first four or so. The second team have to beat the first team's score within these same two constraints.

The optimisation exercise in either team's task involves choosing some compromise between scoring fast and hence taking higher risks of losing wickets, and playing carefully and hence risking making insufficient runs. Whatever strategy a team adopt, they are always compromising between the constraints on their two resources, overs and

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wickets. But when an innings has to be shortened, only one of these resources, overs, is depleted and the balance is upset.

The most common method used in the past for deciding the result of a game, shortened after its start, is to award victory to the team with the highest average run rate, measured in runs per over available. This is usually unfair to one or other of the teams, depending on the situation at the time of the stoppage, as we shall show.

In this paper we briefly review the methods that have been used in the past and explain their deficiencies. We then present the basis for our method which is a relationship for the proportion of the runs of an innings which may be scored for any combination of the two resources a batting side possesses, overs to be faced and wickets in hand. From this we produce a table from which may be determined the proportion of the run scoring resources remaining at any stage of an innings, and hence the proportion of these resources lost by an interruption. We then show how to use the total resources available to the two teams to provide a simple but fair correction to the target score of the team batting second.

Review of other methods

The following are methods that have been used so far in one-day cricket together with a brief description. 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.

- *Average run rate (ARR)*. 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.
- *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 1'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, by a young South African (do Rego[8]), calculates a table of 'norms' y, (reproduced in Table 1) for overs of an innings, x, using the parabola $y = 7.46x - 0.059x^2$ to model, rather inappropriately since it has a turning point (at about 63 overs, the 'diminishing returns' nature of the relationshiop 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.
- *World Cup 1996 (WC96)*. This is an adaptation of the PARAB method. Each of the norms has been converted into a percentage, shown in Table 1, of 225 as an approximation for the 50 over norm and generally regarded as the mean of first innings scores in one-day international matches.
- *Clark Curves (CLARK)*. This method, fully described on the Internet,[9] 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 innings commences, during the innings, or to terminate the innings. It applies different rules for each type of stoppage 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 Duckworth/Lewis method (D/L)

Model development

Our aims have been to produce a method of correction which satisfies what we believe to be five important criteria for acceptability.

Table 1 Norms and percentage factors for the PARAB and WC96 methods

Overs					25	26	27	28	29	30
PARAB norm					150	154	158	163	167	171
WC96 factor					66.7	68.4	70.2	72.4	74.2	76.0
Overs	31	32	33	34	35	36	37	38	39	40
PARAB norm	175	178	182	185	189	192	195	198	201	204
WC96 factor	77.8	79.1	80.9	82.2	84.0	85.3	86.7	88.0	89.3	90.7
Overs	41	42	43	44	45	46	47	48	49	50
PARAB norms	207	209	212	214	216	218	220	222	224	226
WC96 factor	92.0	92.9	94.2	95.1	96.0	96.9	97.8	98.7	99.6	100

1. It must be equally fair to both sides; that is the relative positions of the two teams should be exactly the same after the interruption as they were before it.
2. It must give sensible results in all conceivable situations.
3. It should be independent of Team 1s scoring pattern, as indeed is the target in an uninterrupted game.
4. It should be easy to apply, requiring no more than a table of numbers and a pocket calculator.
5. It should be easy to understand by all involved in the game, players, officials, spectators and reporters.

The basis of our method is that it recognises that the batting side has two resources at its disposal from which to make its total score; it has *overs* to face and it has *wickets* in hand. The number of runs that may be scored from any position depends on both of these resources in combination. Clearly, a team with 20 overs to bat with all ten wickets in hand has a greater run scoring potential than a team that has lost, say, eight wickets. The former team have more run scoring resources remaining than have the latter team although both have the same number of overs left to face.

The way our method works is to set Team 2s target score to reflect the relative resources they have compared with Team 1. We therefore need a two-factor relationship between the proportion of the total runs which may be scored and the two resources, overs to be faced and wickets in hand. To obtain this it is necessary to establish a suitable mathematical expression for the relationship and then to use relevant data to estimate its parameters.

The average total score $Z(u)$ which is obtained in u overs may be described by the exponential equation

$$Z(u) = Z_0[1 - \exp(-bu)] \quad (1)$$

where Z_0 is the asymptotic average total score in unlimited overs (but under one-day rules) and b is the exponential decay constant.

The next stage of development of a suitable two-factor relationship is to revise (1) for when w wickets have already been lost but u overs are still left to be received. The asymptote will be lower and the decay constant will be higher and both will be functions of w.

The revised relationship is of the form

$$Z(u, w) = Z_0(w)[1 - \exp\{-b(w)u\}] \quad (2)$$

where $Z_0(w)$ is the asymptotic average total score from the last 10-w wickets in unlimited overs and $b(w)$ is the exponential decay constant, both of which depend on the number of wickets already lost.

Commercial confidentiality prevents the disclosure of the mathematical definitions of these functions. They have been obtained following extensive research and experimentation so that $Z(u, w)$ and its first partial derivative with respect to u behave as expected under various practical situations and give sensible results at the boundaries.

Figure 1 shows the family of curves described by (2) using parameters estimated from hundreds of one-day internationals.

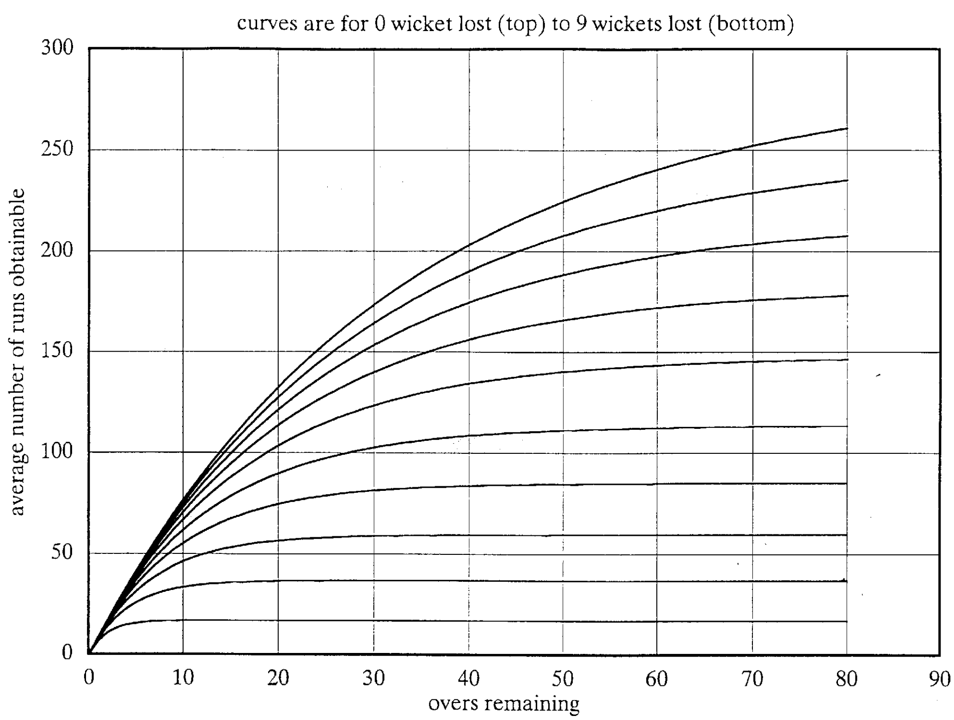

Figure 1 Average number of runs from overs remaining with wickets lost.

If we now write (2) for the start of an N over innings ($u = N$ and $w = 0$), we have

$$Z(N, 0) = Z_0[1 - \exp\{-bN\}]$$

and the ratio

$$P(u, w) = Z(u, w)/Z(N, 0) \quad (3)$$

gives the average proportion of the runs still to be scored in an innings with u overs to be bowled and w wickets down. It thus gives the proportion of the combined run scoring resources of the innings remaining when u overs are left and w wickets are down, and this provides a single table of proportions from which the correction for an interruption may be made for any target score. An extract is provided, in Table 2, for the purposes of demonstrating how the method works in several hypothetical situations.

Application to interruptions in Team 2's innings

To reset the target when overs have been lost due to an interruption we need to calculate the proportion of the run scoring resources of the innings that have been lost. Let us suppose that Team 1 have completed their innings, using up 100% of their available resources, and have scored S runs. Team 2 are replying when a stoppage occurs with w wickets down and u_1 overs left. When play is resumed only u_2 overs may be bowled ($u_2 < u_1$) though of course there are still w wickets down.

Team 2 have been deprived of $u_1 - u_2$ of their overs resource and so their target to win should be adjusted to compensate for this loss. The proportion of the run scoring resources of the innings lost in those $u_1 - u_2$ overs is $P(u_1, w) - P(u_2, w)$ and so their innings resources available are $R_2 = [1 - P(u_1, w) + P(u_2, w)]$. Thus their target score should be reduced in this proportion and it becomes $T = SR_2$. The target score to win is the next higher whole number.

Multiple interruptions are handled similarly, the total proportion of the innings lost being aggregated after each stoppage and the revised target set accordingly. Hypothetical and real examples are provided later in the paper to illustrate how the method works in practice and to show how it succeeds where other methods fail.

Table 2 Percentage of innings resources remaining **(an extract from the table)**

Wickets lost	*0*	*2*	*4*	*9*
Overs left 50	100	83.8	62.4	7.6
40	90.3	77.6	59.8	7.6
30	77.1	68.2	54.9	7.6
25	68.7	61.8	51.2	7.6
20	58.9	54.0	46.1	7.6
10	34.1	32.5	29.8	7.5

Team 2's response may be monitored via the concept of the *par score*. If their target score is T and after x overs have been bowled they have lost w wickets, then they have used up a proportion of their run scoring resources $R_2 = 1 - P(N - x, w)$ and so the score they should have made to be on par for their target is TR_2.

Interruptions to team 1's innings

It often happens that Team 1's innings is interrupted and either prematurely terminated or resumed later to complete a shorter innings. When this happens the match officials try to arrange that both sides still have the same number of overs to face. For example, if during Team 1's innings the time for a total of 20 overs play is lost, Team 1's innings will be shortened by 10 overs and Team 2 will have their innings reduced by the same amount. With all other methods no revised target would be set in this situation.

However, 10 overs lost from the midst of, or especially at the end of, Team 1's innings, constitutes a very different loss of resources compared with 10 overs lost from the beginning of Team 2's innings. In the great majority of instances, Team 1's loss is greater than that of Team 2 and so to make no adjustment to the target is extremely unfair to Team 1. On the other hand if Team 1 had lost many wickets and looked like being bowled out well before the expiry of their full allocation of overs, a loss of overs could constitute very little loss of resource and to make no correction could actually benefit them.

Our method provides a fair target in this situation, again by correcting in accordance with the relative resources the two sides have available. Suppose a stoppage occurs in Team 1's innings so that $u_1 - u_2$ overs are lost when w wickets have fallen. The proportion of the resources of a full uninterrupted innings that was available to Team 1 is $R_1 = 1 - P(u_1, w) + P(u_2, w)$.

Further suppose that if R_2 is that proportion available to Team 2 allowing for the reduced number of overs they are to receive, then the revised target is set by comparing R_1 and R_2. If $R_1 = R_2$ the target score is clearly equal to Team 1's final score, S, and if $R_2 < R_1$, then it is reduced in proportion, that is $T = SR_2/R_1$.

If $R_2 > R_1$, however, a different approach is needed. Merely scaling S in the ratio $R_2 : R_1$ could easily lead to a grossly distorted revised target score, it being an extrapolation beyond the resource available for Team 1. For example, if Team 1 have scored 80/0 after 10 overs and rain reduces the match to 10 overs per side, a direct scaling will use, from Table 2, $R_1 = 1 - 0.903 = 0.097$ and $R_2 = 0.341$ giving $T = 80 \times 0.341/0.097 = 281.24$. This is clearly a preposterous target for 10 overs which is based on the assumption that the well-above-average scoring rate per unit of resource in those 10 overs could be sustained for the full 50 overs. Although there may be factors which affect all players' scoring capabilities equally, such as the condition of the wicket, the speed of the outfield and short or long boundaries, it is highly unlikely that Team 1 would have been able to sustain such a high early scoring rate and a target to win of 282 in 10 overs is unrealistic.

It is clear, however, that since $R_2 > R_1$, Team 2 should have a higher target than Team 1s final score, S. Conscious of the criteria of acceptability for a method of ease of use and understandability, we have adopted the approach that the amount by which the target is increased is obtained by applying the excess resource $R_2 - R_1$ to the average score in the full uninterrupted first innings of matches at the appropriate standard. For international matches between International Cricket Council full member nations and for English domestic competitions involving first-class counties, the average score for a 50 over innings is 225. For matches between associate member countries it is 190. In general the average first innings score for the availability of N overs for any level of competition, denoted by $G(N)$, can be obtained from match records.

The method of calculating the revised target score T following interruptions to either innings is thus as follows:

$$\text{For} \quad R_2 < R_1, \qquad T = SR_2/R_1 \tag{4a}$$

$$\text{For} \quad R_2 = R_1, \qquad T = S \tag{4b}$$

$$\text{For} \quad R_2 > R_1, \qquad T = S + G(N)\,(R_2 - R_1) \tag{4c}$$

The operation of the method is illustrated in Figure 2 where Team 2's target is plotted against the percentage resource of the full innings, R_2, for an arbitrary resource for Team 1 of R_1. The heavy line represents the scoring of the average total $G(N)$ by Team 1 at a uniform rate per unit of innings resource and the other lines show situations where their scoring has been above and below average. The three lines show the required targets for all values of the abscissa, R_2, and the parts of the lines are seen to correspond to the different conditions covered by (4a–c).

Examples of application

Some hypothetical and actual examples are provided below to illustrate how our method produces sensible revised targets under all circumstances. They also show how targets set by other methods usually give targets which are unfair to one side or the other. The targets for the PARAB method has been excluded since its methodology is incorporated into the WC96 method and the revised targets are virtually identical.

Hypothetical examples

For ease of understanding of the application of our method in cases where only Team 2's innings has been interrupted, we shall use the same total score for Team 1 and the same number of overs lost, although the method will, of course, apply to any total score and to any number of overs lost. Throughout all these hypothetical examples we shall assume that Team 1 have completed a 50 over innings ($R_1 = 1$) and scored ($S =$)250 runs and that interruptions to Team 2's innings are of 20 overs in length. The interruptions occur at different stages of the innings and with different numbers of wickets lost.

Table 3 summarises all of the situations and the calculations to obtain our revised target scores. Proportions of innings' resources remaining are taken from Table 2. We also show the results of applying other methods of correction, identified by our abbreviations as defined.

In all these examples our method has provided a fair revised target to win. Other methods, in the main, do not vary the target between the various scenarios. Only the Clark method shows some variation in the target but it gives the same one for some substantially differing scenarios such as between Examples II and IV and Examples III and VI in Table 3. Not surprisingly, therefore, all other methods produce reasonable targets, in our judgement, in a

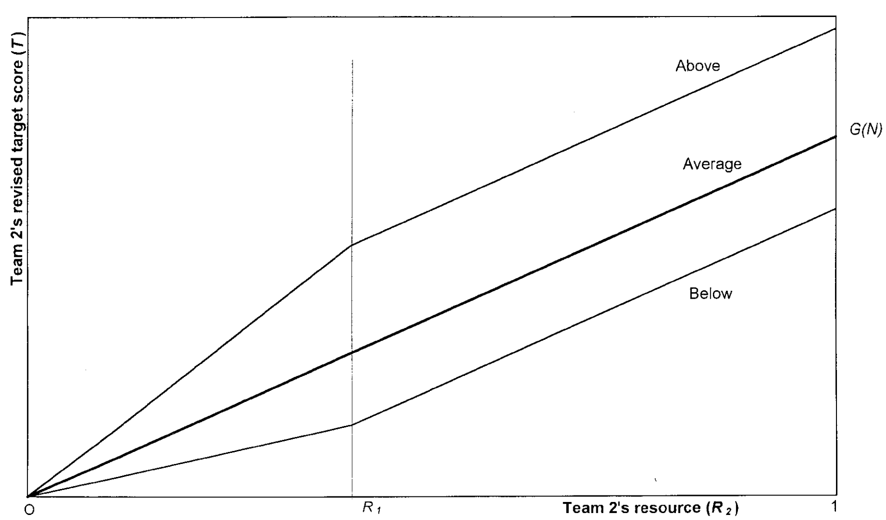

Figure 2 Setting Team 2s target score when Team 1's innings is interrupted.

Table 3 Calculations of the revised target score in hypothetical 50 over examples

Hypothetical example no.	*I*	*II*	*III*	*IV*	*V*	*VI*
Team 2 score, chasing 250($=S$), $R_1 = 1$	0	75	120	75	191	180
Wickets lost, w	0	0	0	2	9	4
Overs left at the stoppage, u_1	50	30	20	30	20	20
Overs left at the stoppage, u_2	30	10	0	10	0	0
Proportion of resources left at resumption $P(u_1, w)$	1	0.771	0.589	0.682	0.076	0.461
Proportion of resources left at resumption $P(u_2, w)$	0.771	0.341	0	0.325	0	0
Proportion lost in $(u_1 - u_2)$ overs $P(u_1, w) - P(u_2, w)$	0.229	0.430	0.589	0.357	0.076	0.461
Proportion available $R_2 = 1 - P(u_1, w) + P(u_2, w)$	0.771	0.570	0.411	0.643	0.924	0.539
Revised target score $T = SR_2$	192.8	142.5	102.8	160.8	231.0	134.8
D/L target to win	**193**	**143**	**103**	**161**	**232**	**135**
OTarget to win from other methods:						
ARR	151	**151**	151	**151**	151	151
WC96	**191**	191	191	191	191	191
MPO[a]	**201**	201	201	201	201	201
DMPO[a]	**181**	181	181	181	181	181
CLARK	**182**	162	134	**162**	201	**134**

[a] The targets by the MPO and DMPO methods cannot be evaluated properly without the actual score cards to find the total of the 30 most productive overs. To obtain some comparative figures we have assumed here that the 20 *least* productive overs yielded 50 runs, half the average run rate. Therefore, the 30 most productive overs yielded 200 runs.

limited number of the various scenarios. These reasonable targets are set in bold type in Table 3.

In their various ways all of these hypothetical examples emphasise strongly that, when resetting the target score, there is a need to consider both the stage of the innings when the overs are lost and also the number of wickets that have fallen at that point. Most of the methods fail to do this, the exception being CLARK and even then not in all circumstances. This method also suffers from problems of discontinuity. In Example I its revised target is 182 when the 20 overs are lost before Team 2 starts its innings. If, instead, the interruption of 20 overs occurs after one ball, the revised target is 159, a difference of 23 for the one ball.

Actual examples

We now include several applications of our method to actual international games. They show, further, how our method yields fair targets when compared to the actual target for the method in use and might well have produced results different from those which actually occurred.

We have taken several examples from the 1992 World Cup in Australia, which used the MPO method. In this tournament a number of matches were affected by rain, some leading to well known and very controversial situations—the England/South Africa match in the semi-final became the catalyst for the search for a better method of target resetting. We have also included a more recent match between New Zealand and England in 1997 in which ARR was used and also two games where Team 1's innings was interrupted. Table 4 summarises the situations for games where only Team 2's innings was interrupted as in the hypothetical examples. The proportion of innings resources remaining have been taken from the full 50 over table which has not been printed in this paper.

Table 4 Calculations of the revised target score in actual matches

Match (Team 1/Team 2)	*RSA/ENG*	*RSA/PAK*	*ENG/RSA*	*NZ/ENG*
Team 1 score, S	236	211	252	253
Overs in the innings	50	50	45	50
Team 2 score	63	74	231	47
Wickets lost, w	0	2	6	0
Overs left at the interruption, u_1	38	29	2.1	44
Overs left at the resumption, u_2	29	15	0.1	20
D/L target to win	**207**	**164**	**234**	**163**
Actual revised target in the match	226	193	252	132
Actual method in use	MPO	MPO	MPO	ARR

RSA = Republic of South Africa; PAK = Pakistan; ENG = England: NZ = New Zealand.

The following two examples show how the method is applied to two games in which Team 1s innings was interrupted. The target set to win is compared with the actual target set in the match.

India vs Pakistan, Singer Cup, Singapore, April 1996—premature termination of the first innings

India had scored ($S=$)226 for 8 wickets in 47.1 out of 50 overs when rain interrupted play. Their innings was terminated and Pakistan were 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 were 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. 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 $R_1 = 91.9\%$ of their resources. With 33 overs to bat Pakistan have $R_2 = 81.5\%$ of their innings resources available. Since $R_2 < R_1$, 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.

England vs New Zealand, World Series Cup, Perth, Australia, 1983—resumption of the first innings

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 were 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 were deprived of 45.3% of their innings resources, hence $R_1 = 54.7\%$. New Zealand, in 23 out of 50 overs, had $R_2 = 65.0\%$ of their innings resources available. Since $R_2 > R_1$, New Zealand's revised target would have been, from (4c) with $G(50) = 225$, $T = 111.18$ 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.

Some actual uses of D/L

Our method has already been used in several one-day competitions. The very first use was on New Years Day, 1997. Zimbabwe scored exactly 200 in 50 overs. Rain during the interval reduced England's innings to 42 overs. ARR would have been given 168 to tie, 169 to win. D/L gave 185 to tie, and 186 to win. England fell between the two scores reaching 179 in 42 overs. Consequently, they lost using our method whereas their score exceeded the ARR target to win.

On 12/13 April 1997 in the final of the ICC Trophy in Kuala Lumpur, a tournament between non-test playing countries, Kenya scored 241 from their 50 overs. Bangladesh's innings was reduced to 25 overs before it commenced. The D/L target was 68.7% of 241, (see Table 2), which gave 166 to win. Bangladesh achieved this target from the very last ball. Our method had provided an exciting game which would probably not have occurred if the ARR target of 121 had been used.

The method received an extensive test during the fairly wet 1997 English summer. Despite some early criticisms from some sections of the media it produced fair targets. The main difficulties have been in communication of the revised target to the public at the grounds and a certain reluctance from some cricket correspondents to prevent mental shutters coming up at the mention and memory of anything mathematical. We feel, however that the method is slowly becoming accepted as part of the English domestic one-day game.

Other aspects of one-day matches

The examples presented in this paper have concentrated on 50 over one-day internationals. Clearly the methodology is applicable to any length of limited overs match and to any standard of competition. Table 2, in full, can be used to handle matches shortened before their start, by scaling the factors from the table (as in the England/South Africa match in Table 4) or, as in the English 1997 season, by having tables available for every length of innings from 60 down to 10 which is the minimum for each side necessary to constitute a match in those competitions.

The method also satisfactorily handles situations such as penalties incurred for slow bowling by Team 2. In the England/South Africa match South Africa only completed 45 of their 50 overs in the time allowed. Although there were substantial financial penalties South Africa did not suffer in cricketing terms. Changes to playing conditions since then are such that the full 50 overs would be bowled to Team 1 but, to win, Team 2 would have to exceed Team 1's total in only 45 overs, which represents a penalty of 4.5% of resources. For any suspensions in play due to the weather D/L takes this penalty into account in resetting the target score. The penalty is applied by attributing Team 1's total score S to less resource than Team 1 actually had available. Thus R_1 is reduced, prior to the application of (4a–c), by the resource penalty corresponding to the number of overs penalty imposed by the umpires.

Conclusions

In this paper we have explained the mechanisms of other methods used for resetting target scores in interrupted one-day cricket matches. Each of these methods yields a fair target in some situations. None has proved satisfactory in deriving a fair target under all circumstances.

We have presented a method which gives a fair revised target score under all circumstances. This is based on the recognition that teams have two resources, overs to be faced and wickets in hand, to enable them to make as many runs as they can or need. We have derived a two-factor relationship which gives the average number of runs which may be scored from any combination of these two resources and hence have derived a table of proportions of an innings for any such combination. This enables the proportion of the resources of the innings of which the batting team are deprived when overs are lost as a result of a stoppage in the play to be calculated simply and hence a fair correction to the target score to be made.

Through the examples given, both hypothetical and real, we have shown that our method gives sensible and fair targets in all situations. They include the circumstances where overs are lost at the start of the innings, part way through, or at the end of an innings and where the game is abandoned requiring a winner to be decided if Team 2's innings is terminated. The examples have shown the importance of taking into account the wickets that have been lost at the time of the interruption and the stage of the innings at which the overs are lost.

Our method was adopted by the England and Wales Cricket Board for the 1997 domestic and Texaco one-day international competitions and the International Cricket Council has used it for several international one-day competitions. We believe that it should be adopted, ultimately, for limited-overs competitions world-wide.

The parameters of our relationship might change as the nature of the game changes due, for instance, to changes in rules or possibly to changes in team selection and playing strategy. While such changes would generally be expected to make little difference to the corrections to a target score, it is nevertheless important that the method of correction keeps abreast with the game. It is our intention that these parameters will be reviewed periodically. This will require the electronic storage of all relevant one-day match data, including scores after each over, and the creation of a permanent database.

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Received August 1997;
accepted November 1997 after one revision