

# MEANINGFUL BATTING AVERAGES IN CRICKET

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## ABSTRACT

In this paper we analyze and compare four different methods, designed to deal with the problem of an inflated batting average due to the presence of a high proportion of not-out innings. Batting records from the 2010 IPL are used to illustrate the properties and shortcomings of each method.

## 1. INTRODUCTION

Historically the principle criterion used for comparing batsmen in the game of cricket has been the batting average. Let  $x_1, x_2, \dots, x_n$  denote the runs scored by a batsman in  $n$  completed innings, and let  $x_{n+1}^*, x_{n+2}^*, \dots, x_{n+m}^*$  denote the runs scored by this batsman in  $m$  not-out innings. The batting average is then defined as the number of runs scored in all innings divided by the number of completed innings,

$$AV = \frac{\text{Number of runs scored}}{\text{Number of completed innings}} = \frac{1}{n} \left( \sum_{i=1}^n x_i + \sum_{i=n+1}^{n+m} x_i^* \right).$$

Unfortunately, when a batsman has a high proportion of not-out innings, the batsman's AV will be inflated. Table 1 gives the batting records of J.H. Kallis and K.P. Pietersen, who both played for the Bangalore Royal Challengers in the 2010 Indian Premier League (IPL). Among all batsmen who had at least four completed innings in the 2010 IPL, Pietersen ( $AV = \frac{236}{4} = 59.00$ ) and Kallis ( $AV = \frac{572}{12} = 47.67$ ) had the highest batting averages. Based on AV, it seems that Pietersen outperformed Kallis as batsman. However, three out of Pietersen's seven innings were not-out innings. Furthermore, Pietersen only had two scores, 66\* and 62, which were higher than his AV and his third highest score was only 29\*. It is therefore debatable whether Pietersen's AV provides a meaningful measure of his batting performance during the 2010 IPL.

The simplest solution for dealing with the problem of inflated batting averages is to use the "real" AV instead of the conventional AV by dividing the number of runs scored in all innings by the total number of innings,

$$AV_{\text{real}} = \frac{\text{Number of runs scored}}{\text{Number of innings}} = \frac{1}{n+m} \left( \sum_{i=1}^n x_i + \sum_{i=n+1}^{n+m} x_i^* \right).$$

With  $AV_{\text{real}}$  the distinction between completed and not-out innings is ignored, and, by doing so, the occurrence of inflated averages is completely eliminated (Howells, 2001). For instance,  $AV_{\text{real}} = \frac{236}{7} = 33.71$  for Pietersen, while  $AV_{\text{real}} = \frac{572}{16} = 35.75$  for Kallis. However, using  $AV_{\text{real}}$  can unfairly penalize a batsman who has to bat when there is only a limited number of balls remaining in the team's batting innings, thus denying the batsman the opportunity to accumulate more runs in that innings. As a hypothetical example, suppose Pietersen had an eighth innings in the 2010 IPL in which he could only face a single ball, scored no runs and was not dismissed. Then his AV would remain 59.00, but he would have  $AV_{\text{real}} = \frac{236}{8} = 29.50$ .

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**Table 1. Detailed batting records of J.H. Kallis and K.P. Pietersen in the 2010 IPL**

Match <sup>†</sup>	J.H. Kallis			K.P. Pietersen		
	Innings	Runs scored	Balls faced	Innings	Runs scored	Balls faced
4	1	65*	52	-	-	-
7	2	89*	55	-	-	-
10	3	44*	34	-	-	-
14	4	66*	55	-	-	-
18	5	19	17	-	-	-
20	6	27	29	-	-	-
28	7	52	49	1	23*	14
31	8	9	10	2	66*	44
35	9	54	42	3	16	19
40	10	68	44	-	-	-
43	11	8	11	-	-	-
46	12	27	37	-	-	-
49	13	0	3	4	62	29
52	14	14	15	5	21	16
57	15	11	9	6	19	14
59	16	19	32	7	29*	21
Total		572	494		236	157

<sup>†</sup> Match number in 2010 IPL; \* Not-out innings; - Did not bat

Various alternative solutions have been suggested for the problem of inflated batting averages. In this paper we consider four different methods. Using batting records from the 2010 IPL, presented and discussed in Section 2, we illustrate the properties and shortcomings for each method and, where applicable, provide improvements on the methods. In particular the batting records of Kallis and Pietersen are used to showcase the calculations for each method. In Section 3 the product limit estimator, a non-parametric estimator for the average, is discussed. Two methods in which not-out batting scores are replaced with adjusted “completed” scores are considered in Section 4, while a method based on exposure-to-risk is analyzed in Section 5. In Section 6 we conclude by comparing the various methods in terms of the selected batsmen from the 2010 IPL.

## 2. BATTING RECORDS FROM THE 2010 INDIAN PREMIER LEAGUE

Due to its huge popularity in the world of cricket, we decided to use batting records from the 2010 edition of the Indian Premier League. The IPL is played under the Twenty20 (or T20) format of cricket in which each team is given a single innings with a maximum of 20 overs. To enable sensible comparisons, we only considered batsmen who faced at least 100 balls and had at least four completed innings. Given these restrictions, we selected the ten batsmen with the highest batting averages (Cricinfo, 2010a). Their batting records were compiled from the scorecards listed on Cricinfo (2010b) and are summarized in Table 2 in descending order based upon *AV*. The detailed batting records of Kallis and Pietersen are given in Table 1. The records of the other eight batsmen are available from the authors on request. Five of the selected batsmen had 13 or more innings each and at least ten completed innings, whereas the other five batsmen had less than ten innings each with only four or five completed innings. All the batsmen except S.R. Watson had at least one not-out innings.

Although the focus in this paper is on batting averages, two other batting criteria are also listed in Table 2. Let  $b_1, b_2, \dots, b_n$  denote the number of balls faced by a batsman in  $n$  completed innings, and let  $b_{n+1}^*, b_{n+2}^*, \dots, b_{n+m}^*$  denote the number of balls faced by this batsman in  $m$  not-out innings. The batsman’s strike rate is then defined as the number of runs scored per  $k$  balls,

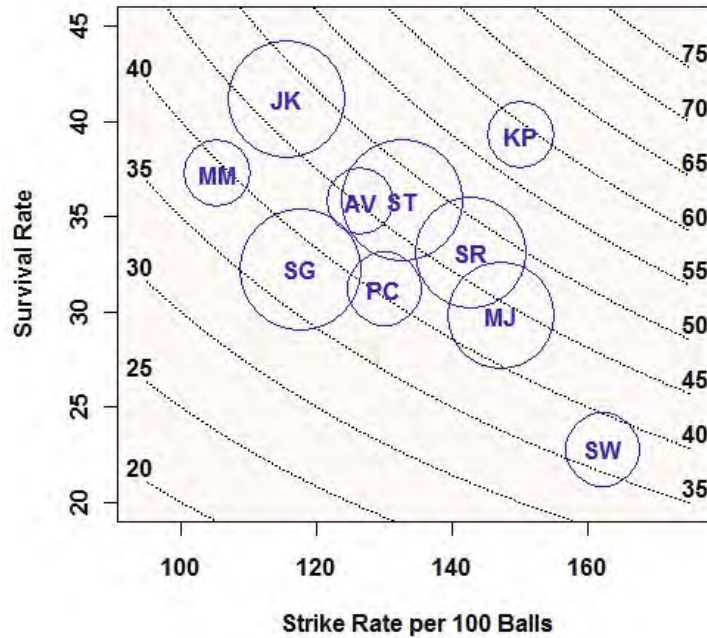
$$SR_k = k \times \frac{\text{Number of runs scored}}{\text{Number of balls faced}} = k \times \frac{\sum_{i=1}^n x_i + \sum_{i=n+1}^{n+m} x_i^*}{\sum_{i=1}^n b_i + \sum_{i=n+1}^{n+m} b_i^*},$$

where  $k$  is usually taken to be 100.

**Table 2. Summary of the batting records of ten selected batsmen from the 2010 IPL**

Batsmen	Code <sup>†</sup>	Innings			Runs Scored	Balls faced	AV <sup>‡</sup>	SR <sub>100</sub> <sup>‡</sup>	SV <sup>‡</sup>
		All	Not-out	Completed					
K.P. Pietersen	KP	7	3	4	236	157	59.00	150.32	39.25
J.H. Kallis	JK	16	4	12	572	494	47.67	115.79	41.17
S.R. Tendulkar	ST	15	2	13	618	466	47.54	132.62	35.85
S.K. Raina	SR	16	5	11	520	364	47.27	142.86	33.09
A.C. Voges	AV	7	3	4	181	143	45.25	126.57	35.75
D.P.M.D. Jayawardene	MJ	13	3	10	439	298	43.90	147.32	29.80
P.D. Collingwood	PC	7	2	5	203	156	40.60	130.13	31.20
M. Manhas	MM	8	4	4	157	149	39.25	105.37	37.25
S.C. Ganguly	SG	14	1	13	493	419	37.92	117.66	32.23
S.R. Watson	SW	5	0	5	185	114	37.00	162.28	22.80

<sup>†</sup> Code used in Figure 1; <sup>‡</sup> AV = batting average, SR<sub>100</sub> = strike rate per 100 balls and SV = survival rate



**Figure 1. Graphical comparison of the batting performances of ten batsmen from the 2010 IPL**

Recently van Staden (2009) defined a third batting criterion which he named the survival rate. The survival rate is the number of balls faced in all innings divided by the number of completed innings,

$$SV = \frac{\text{Number of balls faced}}{\text{Number of completed innings}} = \frac{1}{n} \left( \sum_{i=1}^n b_i + \sum_{i=n+1}^{n+m} b_i^* \right).$$

Since a hyperbolic relation exists between the strike rate, survival rate and batting average,

$$SR_k \times SV = k \times AV,$$

the three criteria can be represented graphically on a single plot in order to compare cricketers' batting abilities (van Staden, 2009). This is done in Figure 1 for the ten selected batsmen from the 2010 IPL. Note that the circles in Figure 1 have radii relative to the number of completed innings. The survival rate will be utilized in Section 5 to augment one of the methods used to estimate the batting average.

### 3. PRODUCT LIMIT ESTIMATOR

Danaher (1989) proposed the product limit estimator (*PLE*) to estimate the batting average. The *PLE* is a non-parametric estimator originally designed by Kaplan & Meier (1958) for the use in life insurance and the actuarial field in general.

With the *PLE*, all not-out batting scores are censored. Then

$$PLE = \sum_{i=1}^n \Delta y_{i:n} \prod_{j=0}^{i-1} \left( 1 - \frac{d_j}{c_j} \right),$$

where  $y_{1:n} < y_{2:n} < \dots < y_{n:n}$  denote the ranked distinct uncensored scores,  $y_{0:n} = 0$ ,  $\Delta y_{i:n} = y_{i:n} - y_{i-1:n}$ ,  $d_j$  is the number of uncensored scores equal to  $y_{j:n}$  and  $c_j$  is the number of censored and uncensored scores greater or equal to  $y_{j:n}$ . To ensure that the *PLE* is finite, the maximum score is uncensored, even if it is a not-out score (as are the cases with both Kallis and Pietersen in the 2010 IPL). The calculation of the *PLE* for Kallis and Pietersen is shown in Table 3. For Kallis,  $PLE = 39.00$ , while for Pietersen,  $PLE = 44.57$ .

Unfortunately the calculation of the *PLE* is extremely complex, so it is unlikely to find favor in the cricket fraternity. Also, after each extra innings of a batsman, the *PLE* has to be recalculated completely. Furthermore, as pointed out by Danaher (1989), the *PLE* is insensitive when many of the high scores are not-out scores and hence censored. For example, suppose Pietersen's second highest score of 62 was also a not-out score, in effect, 62\*. Then his *AV* would be 78.67 instead of 59.00, but his *PLE* would only increase from 44.57 to 45.71. Batsmen would certainly not be impressed by this.

Generally a batsman will always have  $PLE \leq AV$ . However, it is interesting to note that the value of the *PLE* can be greater than that of *AV*. This can happen when a batsman's highest score is an outlier, that is, when the highest score is much larger than the second highest score and, in effect, the rest of the batsman's scores. Suppose Pietersen had the opportunity in his second innings in the 2010 IPL to continue batting and that he was finally dismissed for 120 runs. Then  $\Delta y_{5:5} = y_{5:5} - y_{5-1:5} = 120 - 62 = 58$  and  $PLE = 60.00 > AV = \frac{290}{5} = 58.00$ .

### 4. ADJUSTING NOT-OUT BATTING SCORES

Lemmer (2008a) considered innovative estimators of the type

$$e_g = \frac{1}{n+m} \left( \sum_{i=1}^n x_i + f_g \sum_{i=n+1}^{n+m} x_i^* \right),$$

where the factor  $f_g$  is used to adjust the not-out scores to obtain completed scores. The simplest estimator of this type is  $e_2$  with  $f_2 = 2$ , so that not-out batting scores are doubled. Lemmer (2008a) justified the choice of  $f_2 = 2$  by showing that, if a batsman had a not-out score and assuming that those external factors which could end the batsman's innings without the batsman being dismissed were random and independent of the batsman's potential score, then, on average, he could have been expected to double his score.

Lemmer (2008a) also considered many other possible factors, and found that  $e_6$  with  $f_6 = 2.2 - 0.01\bar{x}^*$ , where

$$\bar{x}^* = \frac{1}{m} \sum_{i=n+1}^{n+m} x_i^*$$

is the average of the not-out batting scores, is the best overall for limited overs batting scores. Lemmer (2008a) showed that  $e_2$  and  $e_6$  are closely related and, because the calculation of  $e_6$  is more complicated than that of  $e_2$ , suggested that  $e_2$  be used for obtaining easy results without compromising accuracy too much.

**Table 3. Calculation of the product limit estimates for J.H. Kallis and K.P. Pietersen in the 2010 IPL**

<i>i</i>	J.H. Kallis						K.P. Pietersen					
	$y_{in}$	$d_i$	$c_i$	$\Delta y_{in}$	$\prod_{j=0}^{i-1} \left(1 - \frac{d_j}{c_j}\right)$	$\Delta y_{in} \prod_{j=0}^{i-1} \left(1 - \frac{d_j}{c_j}\right)$	$y_{in}$	$d_i$	$c_i$	$\Delta y_{in}$	$\prod_{j=0}^{i-1} \left(1 - \frac{d_j}{c_j}\right)$	$\Delta y_{in} \prod_{j=0}^{i-1} \left(1 - \frac{d_j}{c_j}\right)$
0	0	0	16	-	-	-	0	0	7	-	-	-
1	0	1	16	0	1.00	0.00	16	1	7	16	1.00	16.00
2	8	1	15	8	0.94	7.50	19	1	6	3	0.86	2.57
3	9	1	14	1	0.88	0.88	21	1	5	2	0.71	1.43
4	11	1	13	2	0.81	1.63	62	1	2	41	0.57	23.43
5	14	1	12	3	0.75	2.25	66	1	1	4	0.29	1.14
6	19	2	11	5	0.69	3.44						
7	27	2	9	8	0.56	4.50						
8	52	1	6	25	0.44	10.94						
9	54	1	5	2	0.36	0.73						
10	68	1	2	14	0.29	4.08						
11	89	1	1	21	0.15	3.06						
<i>PLE</i>						39.00						44.57

For calculating  $e_2$ , Pietersen’s not-out scores of 23\*, 66\* and 29\* are doubled to 46, 132 and 58 respectively. He then has  $e_2 = \frac{354}{7} = 50.57$ . Doubling the first four not-out scores of Kallis results in  $e_2 = \frac{836}{16} = 52.25$ . Since  $\bar{x}^* = \frac{118}{3} = 39.33$  for Pietersen, it follows that  $f_6 = 1.81$ , so that he has  $e_6 = 47.31$ . Similarly, since  $\bar{x}^* = \frac{264}{4} = 66.00$ , it follows that  $f_6 = 1.54$  and hence  $e_6 = 44.66$  for Kallis. Note that, if a high proportion of a batsman’s not-out scores are large, then  $e_2 > AV$ . For instance,  $e_2 = 52.25 > AV = 47.67$  for Kallis, since all four his not-out scores are quite large. Pietersen only had one large not-out score, so  $e_2 = 50.57 < AV = 59.00$  for him. Lemmer (2008b) therefore recommended that  $e_{26} = \frac{1}{2}(e_2 + e_6)$  should rather be used instead of  $e_2$ . Pietersen and Kallis have  $e_{26} = 48.94$  and  $e_{26} = 48.46$  respectively.

Another simple way of negating the effect of large not-out scores on the value of  $e_2$ , is to restrict the adjustment of these large not-out scores. For instance, we propose that the value of an adjusted score for a batsman should be restricted to the highest score achieved by this batsman in the past tournament or career innings. Thus for Kallis in the 2010 IPL, his first score of 65\* is not doubled, since this batting score was automatically his highest score after his first innings. Similarly his second score of 89\* is also not doubled, since this score became his highest score after his first two innings. His third score of 44\* is doubled to 88, since by then he had proven in the 2010 IPL that he had the ability to score that amount of runs (88 is less than his highest score of 89 obtained in his second innings). His fourth and final not-out score of 66\* is again not doubled, but it is adjusted upwards to 89, which is his highest score up to then. So for Kallis a restricted  $e_2$ , which we will denote  $e_2^r$ , is calculated as  $e_2^r = \frac{639}{16} = 39.94$ . Similar arguments for Pietersen result in his first two not-out scores of 23\* and 66\* not being doubled and his last not-out score of 29\* being doubled to 58 (which is less than 66). He then has  $e_2^r = \frac{265}{7} = 37.86$ .

Damodaran (2006) utilized a Bayesian approach to replace not-out scores with conditional average scores. Consider the series of innings  $t = 1, 2, \dots, n + m$ . If the score in innings  $t$  is a completed score,  $x_t$ , let  $z_t = x_t$ . If the score is a not-out score,  $x_t^*$ , then this score is replaced by

$$z_t = \text{int} \left\{ \frac{\sum_{\ell=1}^{t-1} z_\ell I(z_\ell)}{\sum_{\ell=1}^{t-1} I(z_\ell)} \right\},$$

where  $z_1, z_2, \dots, z_{t-1}$  are the series of completed and/or adjusted scores up to innings  $t - 1$ ,  $I(z_\ell) = 0$  if  $x_t^* \geq z_\ell$  and  $I(z_\ell) = 1$  if  $x_t^* < z_\ell$ .

The estimator for the average is then given by

$$AV_{\text{Bayesian}} = \frac{1}{n+m} \sum_{i=1}^{n+m} z_i .$$

For example, the first two not-out scores of Kallis, 65\* and 89\*, are not adjusted. His third not-out score of 44\* is replaced by the average of his two scores greater than 44, that is,  $\frac{65+89}{2} = 77$ . His fourth not-out score of 66\* is replaced by the average of his highest score (89) and the adjusted score for his third innings (77), that is,  $\frac{89+77}{2} = 83$ . He then has  $AV_{\text{Bayesian}} = \frac{622}{16} = 38.88$ . Similarly Pietersen's first two not-out scores, 23\* and 66\*, are not adjusted, while his final score of 29\* is replaced by the average of his two scores greater than 29, that is  $\frac{66+62}{2} = 64$ . He then has  $AV_{\text{Bayesian}} = \frac{271}{7} = 38.71$ .

## 5. METHOD BASED UPON EXPOSURE-TO-RISK

Maini & Narayanan (2007) proposed a method based upon exposure-to-risk. Let

$$\bar{b} = \frac{\text{Number of balls faced}}{\text{Number of innings}} = \frac{1}{n+m} \left( \sum_{i=1}^n b_i + \sum_{i=n+1}^{n+m} b_i^* \right)$$

be the average number of balls faced by a batsman in his  $m+n$  innings and let  $r_1, r_2, \dots, r_n$  and  $r_{n+1}^*, r_{n+2}^*, \dots, r_{n+m}^*$  denote the batsman's exposure in  $n$  completed innings and  $m$  not-out innings respectively. If the score in innings  $i$  is a completed score,  $r_i = 1$ . In effect, the exposure is one for all completed innings. If the score is a not-out score and  $b_i^* < \bar{b}$ , then  $r_i^* = b_i^* / \bar{b}$ , else  $r_i^* = 1$ . The average is then calculated by

$$AV_{\text{exposure}} = \frac{\sum_{i=1}^n x_i + \sum_{i=n+1}^{n+m} x_i^*}{\sum_{i=1}^n r_i + \sum_{i=n+1}^{n+m} r_i^*} .$$

For Pietersen  $\bar{b} = \frac{157}{7} = 22.43$ . In his first not-out innings he only faced 14 balls, giving him an exposure of  $r_1^* = \frac{14}{22.43} = 0.62$ . In his second not-out innings, he faced 44 balls, so  $r_2^* = 1$ . In his last innings, in which he again was not dismissed, he faced 21 balls, so the corresponding exposure is  $r_7^* = \frac{21}{22.43} = 0.94$ . Thus  $AV_{\text{exposure}} = \frac{236}{6.56} = 35.97$  for Pietersen. In each of his four not-out innings, Kallis faced more balls than his average number of balls faced,  $\bar{b} = \frac{494}{16} = 30.88$ . So for each innings, whether he was dismissed or not, he has an exposure of one and therefore  $AV_{\text{exposure}} = AV_{\text{real}} = 35.75$ .

Although the method developed by Maini & Narayanan (2007) is a novel approach for estimating the batting average, two concerns arise regarding the way they determine the exposure. Firstly, the number of balls faced by a batsman in a not-out innings is compared to the average number of balls faced over the whole tournament or career of this batsman. Thus, the exposure calculated for a not-out innings depends on past and future batting performances, which is not logical. Surely only past batting performances should be used. Note furthermore that with the current method of Maini & Narayanan (2007), the exposure for each past not-out innings must be recalculated each time the batsman bats again. So an immediate advantage of only using past batting performances will be that the exposure for past not-out innings need not be recalculated after each additional innings. The second less serious concern has to do with the calculation of the average number of balls faced. We suggest that a batsman should benefit from surviving the opposition's bowling attack by comparing the number of balls faced in a not-out innings to the survival rate (van Staden, 2009) instead of the average number of balls. Applying both our two adjustments to the exposure-to-risk method means that, if a batting score is a not-out score and  $b_i^* < SV_i$ , where  $SV_i$  is the survival rate for the batsman for all innings up to and including innings  $i$ , then  $r_i^* = b_i^* / SV_i$ , else  $r_i^* = 1$ . We will denote the average based upon our adjusted exposure-to-risk method by  $AV_{\text{survival}}$  to distinguish it from  $AV_{\text{exposure}}$ .

**Table 4. Calculation of exposure based upon the survival rate for J.H. Kallis and K.P. Pietersen in the 2010 IPL**

J.H. Kallis				K.P. Pietersen			
Innings	Balls faced	$SV_i^\dagger$	Exposure	Innings	Balls faced	$SV_i^\dagger$	Exposure
1*	52	52.00	1.00	1*	14	14.00	1.00
2*	55	107.00	0.51	2*	44	58.00	0.76
3*	34	141.00	0.24	3	19	77.00	1.00
4*	55	196.00	0.28	4	29	53.00	1.00
5	17	213.00	1.00	5	16	40.67	1.00
⋮	⋮	⋮	⋮	6	14	34.00	1.00
16	32	41.17	1.00	7*	21	39.25	0.54
			14.04				6.29
			494				157

$^\dagger SV_i$  = survival rate after each innings  $i$ ; \* Not-out innings

In Table 4 the calculation of the exposure using our two adjustments is illustrated for Kallis and Pietersen. For example, Pietersen faced 14 balls in his first innings and was not dismissed. Even so, his exposure is set at one for this innings,  $r_1^* = 1$ . In his second innings he was again not dismissed. He faced 44 balls in this innings, so his survival rate is taken as  $SV_2 = 14 + 44 = 58$ , resulting in an exposure of  $r_2^* = \frac{44}{58} = 0.76$ . After his last innings, where he was again not dismissed, his survival rate was  $SV_7 = \frac{157}{4} = 39.25$ . Since he only faced 21 balls in this innings, his exposure for this innings is  $r_7^* = \frac{21}{39.25} = 0.54$ . So his average based upon exposure using survival rate is  $AV_{\text{survival}} = \frac{236}{6.29} = 37.50$ . Similarly Kallis has  $AV_{\text{survival}} = \frac{572}{14.04} = 40.75$ .

## 6. CONCLUSION

The averages based upon each method discussed in the paper were calculated for the ten batsmen selected from the 2010 IPL and are summarized in Table 5. For each method, the batsmen were ranked in descending order with the rankings given in brackets beneath the corresponding average in Table 5. Clearly  $AV_{\text{real}}$  unfairly penalizes batsmen with not-out scores. Most of the batsmen have much lower values for  $AV_{\text{real}}$  compared to  $AV$ . The only batsmen benefiting from  $AV_{\text{real}}$  are Watson, who was dismissed in all five his innings and hence has  $AV_{\text{real}} = AV$ , and S.C. Ganguly who was only once not-out in 14 innings. The estimates of Lemmer (2008a, 2008b) all give higher values compared to the other methods. This is especially true for  $e_2$ , where, for example, six out of the ten batsmen have  $e_2 > AV$ . The correspondence in the rankings between  $e_2$  and  $e_6$  shows that these two measures are indeed closely related (Lemmer, 2008a). But the large differences between the values of  $e_2$  and  $e_6$  for some of the batsmen, most notably for D.P.M.D. Jayawardene, support the suggestion by Lemmer (2008b) to preferably use  $e_{26}$  instead of  $e_2$ . The reason for the large difference between Jayawardene's values for  $e_2$  and  $e_6$  is that his two highest scores were 110\* and 93\*. Both  $AV_{\text{Bayesian}}$  and  $e_2^r$  are less beneficial to batsmen with high not-out scores compared to the estimates of Lemmer (2008a, 2008b). Interestingly the values of  $AV_{\text{Bayesian}}$  and  $e_2^r$  correspond well with the values of  $PLE$ , as do their rankings. Given the simplicity of calculating  $AV_{\text{Bayesian}}$  and  $e_2^r$  compared to the computational difficulties associated with the  $PLE$ , we suggest using these estimates instead of the  $PLE$ . Finally the exposure-to-risk method yields values for  $AV_{\text{exposure}}$  for the ten batsmen which do not differ much from the values of  $AV_{\text{real}}$ . The reason is that in most of their not-out innings the batsmen faced more balls than the average number of balls. The only notable difference between  $AV_{\text{exposure}}$  and  $AV_{\text{survival}}$  is the change in ranking between Kallis and Watson. This is due the use of the survival rate for  $AV_{\text{survival}}$ . Note from Figure 1 that Kallis had the highest survival rate, whereas Watson had by far the lowest survival rate.

None of the methods considered clearly outperforms all the other methods. Choice of method is a function of the statistical literacy of the various role-players within cricket. It should furthermore be emphasized that our conclusions are based on the values obtained for the ten selected batsmen who played in the T20 format of the game. Generalizations to other forms of the game (Tests, first class matches and other limited overs matches) can only be made once the methods have been applied to batting records from these forms of the game. This is currently part of ongoing research.



**Table 5. Summary of the batting averages of ten selected batsmen from the 2010 IPL**

Batsmen	$AV$	$AV_{real}$	$PLE$	$e_2$	$e_6$	$e_{26}$	$e_2^r$	$AV_{Bayesian}$	$AV_{exposure}$	$AV_{survival}$
P.D. Collingwood	40.60 (7)	29.00 (8)	30.86 (8)	47.00 (6)	39.26 (6)	43.13 (6)	32.43 (8)	30.86 (8)	29.00 (8)	29.30 (9)
S.C. Ganguly	37.92 (9)	35.21 (4)	36.14 (7)	40.57 (8)	37.63 (8)	39.10 (8)	36.14 (6)	36.14 (5)	35.21 (5)	35.21 (5)
D.P.M.D. Jayawardene	43.90 (6)	33.77 (5)	38.20 (4)	51.38 (4)	41.46 (5)	46.42 (5)	35.08 (7)	35.08 (7)	34.93 (6)	33.96 (6)
J.H. Kallis	47.67 (2)	35.75 (3)	39.00 (3)	52.25 (1)	44.66 (3)	48.46 (3)	39.94 (2)	38.88 (2)	35.75 (4)	40.75 (2)
M. Manhas	39.25 (8)	19.63 (10)	22.58 (10)	32.00 (10)	31.41 (10)	31.71 (10)	21.88 (10)	22.75 (10)	20.83 (10)	24.44 (10)
K.P. Pietersen	59.00 (1)	33.71 (6)	44.57 (1)	50.57 (5)	47.31 (1)	48.94 (1)	37.86 (3)	38.71 (3)	35.97 (3)	37.50 (3)
S.K. Raina	47.27 (4)	32.50 (7)	37.98 (5)	51.69 (3)	43.74 (4)	47.72 (4)	36.94 (5)	35.69 (6)	32.50 (7)	32.54 (7)
S.R. Tendulkar	47.54 (3)	41.20 (1)	41.83 (2)	51.87 (2)	45.47 (2)	48.67 (2)	41.20 (1)	41.20 (1)	41.20 (1)	41.20 (1)
A.C. Voges	45.25 (5)	25.86 (9)	29.43 (9)	41.57 (7)	38.95 (7)	40.26 (7)	28.29 (9)	27.71 (9)	25.86 (9)	29.59 (8)
S.R. Watson	37.00 (10)	37.00 (2)	37.00 (6)	37.00 (9)	37.00 (9)	37.00 (9)	37.00 (4)	37.00 (4)	37.00 (2)	37.00 (4)

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