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Vani K. Borooah, *University of Ulster*
John E. Mangan, *University of Queensland*

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The "Bradman Class": An Exploration of Some Issues in the Evaluation of Batsmen for Test Matches, 1877-2006

Vani K. Borooah and John E. Mangan

Abstract

The assessment of batsmen in cricket is largely based upon their average score: a Test average of 50 or over provides a rule-of-thumb for distinguishing great players from the merely good; Donald Bradman, with the highest Test average ever achieved (99.94), is generally regarded as the greatest of all batsmen even though many of his other achievements have been eclipsed. However, a ranking based on simple averages suffers from two defects. First, it does not take into account the consistency of scores across innings: a batsman might have a high career average but with low scores interspersed with high ones; another might have a lower average but with much less variation in his scores. Second, it pays no attention to the "value" of the player's runs to the team: arguably, a century, when the total score is 600, has less value compared to a half-century in an innings total of, say, 200. The purpose of this paper is to suggest new ways of computing batting averages which, by addressing these deficiencies, complement the existing method and present a more complete picture of batsmen's performance. Based on these "new" averages, the paper offers a revised ranking of the top fifty batsmen in the history of Test cricket.

KEYWORDS: batting averages, inequality, measures, consistency, adjustment, value-to-team

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1. Introduction

Batsmen in cricket are most usually ranked according to their batting average. Judged on this basis, Donald Bradman was the greatest of all Test batsmen: he retired in 1948 with a career average of 99.9 which towers above Graeme Pollock's, the batsman with the next highest career average, 60.9.¹ In 1949, he became the only Australian cricketer to be knighted. In 1988, the Australian Confederation of Sport voted him greatest male athlete of the past 200 years.

Many of the records set by Bradman have, since his retirement in 1948, been surpassed: Sachin Tendulkar holds the record for the largest number of Test centuries (47 to Bradman's 29); Brian Lara for the highest individual Test score (400 to Bradman's 334); Graham Gooch for the most runs in a Test match (456 to Bradman's 334); Mohammed Yusuf for the highest number of runs in a calendar year (1,788 to Bradman's 1,025).² Yet, notwithstanding these disparate achievements, by assorted batsmen, the Bradman legend survives and, indeed, shows no sign of diminishing with the centenary of his birth in 2008 - 60 years after he retired from Test cricket - being celebrated throughout the cricketing world.

The durability of Bradman's fame naturally raises the general question of whether a batting average, on which his legend is primarily based, is the best means of judging the worth of a batsman.³ This paper argues that the batting average, conventionally calculated as the ratio of the total runs scored to the number of completed innings, might usefully be refined in two ways. The first is by incorporating the notion of consistency into the calculation of averages. Ranking batsmen by their averages does not take into account variations in scores across matches: a batsman with a high career average might have low scores interspersed with high ones; another might have a lower average but with much less variation in scores.⁴ The overall batting records of our top fifty batsmen

¹ In his first international tour (1930) Bradman made 2960 runs (with a batting average of 98.7), including 10 centuries. In his final tour 18 years later, he made 2428 runs with an 89.9 batting average, including 11 centuries.

² In addition to his career average, there are, also, three Bradman records that continue to stand: the highest score in a day (309 at Headingley, 11th July, 1930); the largest number of runs in a series (974 against England in 1930); and fewest innings between centuries (29 centuries in 80 innings or a century every three appearances at the crease).

³ Since Bradman's retirement, international cricket has changed in many ways: more Test playing nations and more Test matches; wider and heavier bats, protective helmets, more standardised pitches; technology assisted umpiring decisions; new forms of cricket in 50 and 20 over matches. In addition, players are now full time professionals who play much more cricket than players of Bradman's generation did.

⁴ A case in point is the batting performance of V.G Kamble. He played in 17 test matches (21 separate innings) for India between the years 1992/93 to 1995/96 and compiled an impressive batting average of 54.2. He had two large innings, 224 in the first innings of the third test versus

shows that it is possible to compile a high average while, at the same time, displaying considerable inconsistency.

In addressing the issue of *consistency*, the paper, borrowing from the methods of inequality analysis, suggests a way of evaluating batsmen by combining the two criteria of career average and career consistency. The type of problem articulated above with respect to batting scores is well known in welfare economics and the analysis of inequality. Anand and Sen (1997), in a paper prepared for the 1995 *Human Development Report*, pointed out that a country's non-economic achievements were likely to be unequally distributed between subgroups of its population: for example, in terms of gender equality, which was the focus of their concern, the female literacy rate, or female life expectancy, was often lower than that for males. Sen (1998) showed that if μ is the mean level of achievement, and I the degree of inequality in its distribution, then the level of social welfare, W , may be represented as $W = \mu(1 - I)$: "this has the intuitive interpretation as the size of the pie (μ) corrected downwards by the extent of inequality (I)" (p. 129).⁵

In this paper we apply this notion of a trade-off between average and distribution by adjusting the average score of a batsman by the degree of inconsistency (or inequality) in his scores to derive a "consistency-adjusted" average (CAA) score. We then contrast the ranking implied by the CAA scores with the more conventional ranking obtained through ("consistency-unadjusted") average (CUA) scores.⁶

The second is by quantifying the value of a batsman's runs to his team. A ranking based on averages pays no attention to the *value* of the player's runs to the team: arguably, a century, when the total score is 600, has less value compared to a half-century in an innings total of, say, 200. While, cricket has not

England at Wankhede in 1992/93 and 227 in the first test, versus Zimbabwe at Dehli in 1993/94. However, his batting, on an innings by innings basis, showed a high degree of inconsistency. He scored below his average in 70% of his innings, had a batting score standard deviation of 69, and scored below 20 in 50% of his innings.

⁵ Pursuing this line of reasoning, Anand and Sen (1997) argued that a country's achievement with respect to a particular outcome should not be judged exclusively by its mean level of achievement (for example, by the average literacy rate for a country) but rather by the mean level *adjusted to take account of inter-group or inter-personal differences in achievements*. Anand and Sen (1997) compared Honduras (with an average literacy rate of 75%, distributed between men and women as 78%, 73%) with China (with an average literacy rate of 80%, distributed between men and women as 92%, 68%) and asked which country should be regarded as having the "better" achievement with regard to literacy: China with a higher overall rate or Honduras with greater gender equality?

⁶ In this sense we are observing consistency of output (scores) and implicitly assuming this is entirely determined by the personal characteristics of the player (Rushall, B. S and Sherman, C. A. (1987). Later in the paper we consider other factors that may influence individual performance such as team needs and managerial tactics

fully established a batting role analogous to baseball's "pinch hitter", tactical and "needs-based" batting (the timing of an innings and the speed at which runs are accumulated) has always played a key role in team strategy (Brooks, Faff and Sokulsky, 2002).⁷ In some circumstances batsmen may be required to chase quick runs and risk getting out to the detriment of their average. Lower order batsmen in our all time top fifty, such as Gilchrist, were more likely to face this situation because they were susceptible to a tactical re-ordering of the batting line up.⁸

The first and most basic question in calculating batting averages is whether the total number of runs should be divided by the number of *completed* innings (as is conventional) or by the number of innings whether completed or not (as proposed by Elderton, 1945; Wood, 1945). Kimber and Hansford (1993) addressed the issue of "not-out" scores and concluded that the Elderton (1945) and Woods (1945) proposal to treat not-out scores as completed innings was flawed because it ignored the *potential* that an incomplete inning had of leading to a higher score when (hypothetically) it was completed. On the other hand, the conventional average, based on not-out innings, was also flawed because it was inconsistent with the underlying mean score.⁹ Kimber and Hansford's (1993) suggested solution was to convert each "not out" innings, *in which the batsman made his highest completed score*, to an estimated completed score and add this to the average.¹⁰

A second question related to the computation of averages is whether there is an underlying probability distribution to the individual scores. Kimber and Hansford (1993) investigated this issue in the context of a geometric model and concluded that this did not provide a good fit to sets of scores for individual batsmen; others have used the lognormal distribution (Bailey and Clarke, 2004), the negative binomial (Ganesalingam, *et. al.*, 1994). More recently, Bracewell and Ruggiero (2009) have used a mixed distribution, which they call 'Ducks and

⁷ The pinch hitter in baseball is a player, often not a first choice player, but through qualities of temperament is often called upon during crisis situations or when a home run or base hit is required quickly to turn the direction of the game. The role is extending into cricket through circumstances now occurring in one-day cricket and particularly the 20-20 version of cricket. See, Krautmann (1990) and Chatterjee, Campbell and Wiseman (1994)

⁸ The issue of the relationship between team needs and individual performance is highlighted in Brooks, Faff and Sokulsky (2002) in which their ordered response model of test cricket performance is less predictive in matches that were rain affected or involved a final innings run chase.

⁹ In the sense, it would not converge to the underlying (and unobserved) mean score as the number of innings increased.

¹⁰ By contrast, in the conventional calculation of an average, *every* not out score is converted to a completed score and added to the average. Suppose a batsman played N innings of which M were completed and N-M were not out scoring X runs in his completed innings and Y runs in his not out innings. Then his average is $\frac{X+Y}{M} = \frac{X}{M} + \frac{Y}{M}$

Runs', in which a beta distribution models zero scores (ducks) and a geometric distribution models non-zero scores (runs).¹¹

Underpinning the analysis of distributions is a distinction between the *measurement* of inequality and the *modelling* of inequality. For example, in the field of economic inequality, there is considerable attention paid to designing satisfactory measures of inequality (*inter alia* Gini, Atkinson index, Theil index) and to modelling inequality, in say incomes, in terms of an underlying distribution (*inter alia* lognormal, Pareto).¹² This paper - unlike the papers cited above which are concerned with modelling - focuses on the measurement of inequality in the distribution of scores of batsmen.

Against this background, the purpose of this paper is to suggest new ways of computing batting averages which, by addressing these deficiencies, complement the existing method and, thereby, present a more complete picture of a batsman's performance. Based on these "new" averages, this paper offers a "new" ranking of the top fifty batsmen in the history of Test Cricket.¹³ In order to allay the fears of the purists it should be made clear that the new ways of computing batting averages, suggested in this paper, are generalisations of the traditional method. Their advantage is that they provide different perspectives for judging batting excellence and highlight the sensitivity of sports rankings to the specific strengths and weakness of sportsmen.

2. Consistency and Batting Performance

The first column of Table 1 shows, of the fifty players in the history of Test cricket (1877-2006) with the highest batting averages - and who had played at least 20 Test innings - Bradman headed the ranking with an average of 100 (famously 99.94, but rounded to the nearest run) while a clutch of nine batsmen brought up the rear with an average of 48.¹⁴ The subsequent column, headed 'Gini', measures the consistency in their scores using the *Gini coefficient*.

¹¹ In addition to the works cited earlier in this paper, Preston and Thomas (2002) and Brooks *et al.* (2002) also represent contributions to the burgeoning quantitative analysis of cricket.

¹² See Champowne and Cowell (1998) for a discussion of measurement and modelling issues.

¹³ One implication from this type of exercise, not pursued in this paper, is the adoption of new or augmented criteria which could lead to some players being omitted from the top 50 and others being added

¹⁴ For all players who had played at least 20 innings in all Test Matches up to, and including, 13 March 2006 (India versus England, Mohali). The criterion of a minimum of 20 test innings is used by the authoritative cricketing website, www.cricinfo.com, in compiling Test averages.

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Table 1
Top Fifty Batsmen in Test Cricket* : 1877-2006**

Rank Based on average	Player	Average	Innings	Gini	Gini adjusted average: Average×(1-Gini)	Rank based on Gini adjusted average	Difference between col 1 and col 8 rank
1	Bradman, D.G	100	80	0.47	53	1	0
2	Pollock, R.G	61	41	0.49	31	5	-3
2	Headley, G.A.	61	40	0.52	29	7	-5
2	Sutcliffe, H	61	84	0.40	36	2	0
3	Paynter, E	59	31	0.48	31	5	-2
3	Barrington, K.F	59	131	0.44	33	3	0
3	Weekes, E.C	59	81	0.49	30	6	-3
3	Hammond, W.R	59	140	0.48	30	6	-3
4	Dravid, R.S	58	167	0.45	32	4	0
4	Sobers, G.S	58	160	0.46	31	5	-1
4	Ponting, R.T.	58	166	0.46	31	5	-1
5	Kallis, J.H	57	161	0.42	33	3	+2
5	Hobbs, J.C	57	102	0.44	32	4	+1
5	Walcott, C.L	57	74	0.46	31	5	-1
5	Hutton, L	57	138	0.46	31	5	0
6	Tendulkar, S.R	56	209	0.50	28	8	-2
7	Tyldesley, G.E	55	20	0.41	33	3	+4
8	Davis, C.A.	54	29	0.39	33	3	+5
8	Kambli, V.G	54	21	0.60	22	13	-5
8	Hayden, M.L	54	141	0.48	28	8	0
8	Chappell, G.S	54	151	0.48	28	8	0
8	Nourse, A.D	54	62	0.45	30	6	+2
8	Sehwag, V	54	72	0.56	24	12	-4
9	Lara, B.C	53	216	0.56	24	12	-3
9	Miandad, J	53	189	0.47	28	8	+1
10	Inzamam U.H	52	177	0.48	27	9	+1
10	Ryder, J	52	32	0.45	28	8	+2
10	Flower, A	52	112	0.44	29	7	+3
10	Smith G.C	52	75	0.53	25	11	-1
11	Gavaskar, S.M	51	214	0.51	25	11	0
11	Waugh, S.R	51	260	0.45	28	8	+3
11	Mohammad, Y	51	108	0.50	26	10	+1
11	Border, A.R	51	265	0.42	29	7	+3
12	Richards, I.V.A	50	182	0.50	25	11	+1
12	Gilchrist, A.C	50	116	0.47	27	9	+3
12	Compton, D.C.S	50	131	0.48	26	10	+2
12	Worrell, F.M.M	50	87	0.51	24	12	0
13	Mead, C.P	49	26	0.52	24	12	+1
13	Bland, K.C.	49	39	0.37	31	5	+8
13	Mitchell, B	49	80	0.46	27	9	+4
13	Jackson, F.S	49	33	0.47	26	10	+3
14	Khan, Y	48	74	0.55	22	13	+1
14	Harvey, R.N	48	137	0.51	24	12	+2
14	Walters, D.S	48	125	0.47	26	10	+4
14	Ponsford, W.H	48	48	0.54	22	13	+1
14	McCabe, S.J	48	62	0.50	24	12	+4
14	Jardine, D.R	48	33	0.36	31	5	+9
14	Martyn, D.R	48	98	0.45	26	10	+4
14	Dexter, E.R	48	102	0.47	25	11	+3
14	Jayawardene, D.P.	48	123	0.47	25	11	+3

*Minimum of 20 innings and averages rounded to the nearest run;

**Australia versus England, 15-19 March 1877, Melbourne; India versus England, 9-13 March 2006, Mohali.

The Gini coefficient is one of the most popular methods for computing inequality in the distribution of outcomes. Its use in sports economics dates back to El-Hadiri and Quirk (1971) who argued that predictability of results (caused by strong team domination of the competition) impacted negatively upon spectator interest. Since then numerous studies have applied the Gini coefficient to measure the competitive balance (evenness of results) in a number of sporting competitions including the US sporting “cartels” of the National Hockey League (Richardson, 2000), Major League Baseball (Burger and Walters, 2003) and the National Football League (Larsen, Fenn and Spenner, 2006) as well as the Australian Football League (Booth, 2004). In this paper, we apply the Gini coefficient to individuals rather than to sporting competitions use the results to measure the consistency of individual performance rather than the degree of competitive balance.

Applied to cricket, if N is the number of innings a batsman has played, of which M were “completed” (i.e. he was given out), R_i is the number of runs scored by a batsman in innings i ($i=1\dots N$), and $\mu = \sum_{i=1}^N R_i / M$ represents his consistency unadjusted score (CUA) - i.e. his cricketing “average”, the Gini coefficient associated with his scores is defined as:

$$G = \frac{1}{2N^2\mu} \sum_{i=1}^N \sum_{j=1}^N |R_i - R_j|$$

In other words, the Gini coefficient is computed as half the mean of the difference in scores between pairs of innings, divided by the average score (μ).¹⁵ So, $G=0.45$ implies that the *difference in scores between two innings chosen at random* will be 90 percent of the average score: if $\mu=50$, this difference will be 45 runs.

Using the Gini values, the CAA scores for every batsmen were computed as $CAA = CUA \times (1-G)$. Suppose that batsmen are viewed as run producing machines of varying degrees of efficiency; every time a “batsman machine” is started he/it would score, *with certainty*, the *same* number of runs before stopping. The CAA represents the “certainty score” of a batsman: a “Bradman machine” would produce X runs ($CAA=X$) before stopping whereas, say, a less efficient “Jardine machine” would produce Y runs ($CAA=Y$), $Y < X$.

¹⁵ Note that the “average” score in cricket, which computed over *all completed* innings, is different from the mean score which is computed over *all* innings whether completed or not. The formulation of the Gini used here – modified to fit cricketing conventions - is slightly different from the conventional formulation which uses the mean in the denominator

The results for this exercise for the top fifty batsmen in Test cricket are shown in Table 1. The position of a number of batsmen remains unchanged under both ranking criteria: Bradman, Sutcliffe, Barrington, Dravid, Hutton, Hayden, Chappell, Gavaskar, and Worrell. The biggest *losers* under the CAA rankings were: Kambli (fell from joint 8th under CUA to joint 13th under CAA), Headley (fell from joint 2nd under CUA to joint 7th under CAA), and Sehwag (fell from joint 8th under CUA to joint 12th under CAA). The biggest *gainers* under the CAA rankings were: Jardine (rose from joint 14th under CUA to joint 5th under CAA), Bland (rose from joint 13th under CUA to joint 5th under CAA), and Davis (rose from joint 8th under CUA to joint 3rd under CAA).

Although Test Match conditions vary from match to match, there are two general sets of circumstances which could affect a batsman's performance. First, his performance may be influenced by whether he is batting in the first or second innings: some batsmen are temperamentally better first innings players, scoring most heavily when the match is in its early stages; others are better second innings players, thriving in the latter stages of a match. Another partial explanation for differing performance between first innings and second innings batting performance (at least, implicitly) relates to the concept of Bayesian updating, whereby the batsmen (or the team management) adjust their current response to the game on the basis of information from the first innings performance of both teams.¹⁶ Most teams come into a game with some prior expectations about the likelihood of winning (based on past results and current events such as injuries and recent form, weather and pitch conditions) but, within the context of such a prior, the objective, at the game's start, is usually to score as many runs as possible in the first innings and set the platform for a winning push in the second innings.¹⁷ As the game unfolds, the likely results of the game are reassessed and the style of play modified. For example, batsmen might be required to go for quick runs or they may be required to concentrate on survival. As argued earlier, it is batsmen lower down the order or those with a proven ability to score runs quickly (the pinch hitter) or to occupy the crease that are most likely to be effected by tactical batting.

¹⁶ See, Yang and Swartz (2004) for the use of a two-stage Bayesian model in predicting behaviour in Major League Baseball,

¹⁷ For example, of the 1789 tests where both innings were completed by the host country, the first innings score exceeded the second innings score in 1221 occasions.

Table 2
1st and 2nd Innings Certainty Scores for the Top Fifty Batsmen in Test Cricket: 1877-2006

Rank Based on average	Player	Average	Innings	Average 1 st innings	Average 2 nd Innings	Certainty Score (CAA) 1 st Innings	Certainty Score (CAA) 2 nd Innings
1	Bradman, D.G	100	80	98	105	46	68
2	Pollock, R.G	61	41	65	55	27	38
2	Headley, G.A.	61	40	66	55	35	23
2	Sutcliffe, H	61	84	59	64	35	39
3	Paynter, E	59	31	62	52	29	35
3	Barrington, K.F	59	131	66	45	38	26
3	Weekes, E.C	59	81	71	37	38	20
3	Hammond, W.R	58	140	64	48	31	29
4	Dravid, R.S	58	167	62	51	32	31
4	Sobers, G.S	58	160	59	55	30	33
4	Ponting, R.T.	58	166	63	49	32	30
5	Kallis, J.H	57	161	55	62	28	43
5	Hobbs, J.C	57	102	64	46	36	28
5	Walcott, C.L	57	74	59	52	31	31
5	Hutton, L	57	138	66	42	34	25
6	Tendulkar, S.R	56	209	61	46	30	25
7	Tyldesley, G.E	55	20	60	41	37	26
8	Davis, C.A.	54	29	49	62	30	40
8	Kambli, V.G	54	21	69	9	32	5
8	Hayden, M.L	54	141	54	54	26	31
8	Chappell, G.S	54	151	59	46	29	27
8	Nourse, A.D	54	62	52	57	27	34
8	Schwag, V	54	72	72	24	34	12
9	Lara, B.C	53	216	65	38	29	18
9	Miandad, J	53	189	57	43	29	26
10	Inzamam U.H	52	177	54	49	26	28
10	Ryder, J	52	32	57	44	31	25
10	Flower, A	52	112	49	56	27	33
10	Smith G.C	52	75	59	40	25	23
11	Gavaskar, S.M	51	214	51	51	24	27
11	Waugh, S.R	51	260	60	33	34	19
11	Mohammad, Y	51	108	60	37	31	20
11	Border, A.R	51	265	48	55	26	34
12	Richards, I.V.A	50	182	51	49	24	28
12	Gilchrist, A.C	50	116	55	38	30	20
12	Compton, D.C.S	50	131	50	49	24	30
12	Worrell, F.M.M	49	87	62	32	30	17
13	Mead, C.P	49	26	57	34	28	17
13	Bland, K.C.	49	39	37	69	21	50
13	Mitchell, B	49	80	43	57	21	35
13	Jackson, F.S	49	33	64	24	39	12
14	Khan, Y	48	74	55	40	25	18
14	Harvey, R.N	48	137	56	36	27	19
14	Walters, D.S	48	125	53	39	27	23
14	Ponsford, W.H	48	48	61	26	28	15
14	McCabe, S.J	48	62	48	48	22	28
14	Jardine, D.R	48	33	44	60	27	42
14	Martyn, D.R	48	98	47	49	25	29
14	Dexter, E.R	48	102	51	43	27	23
14	Jayawardene, D.P.	48	123	55	34	28	22

It is in part for these reasons that 80% our top fifty batsmen scored most heavily in the first innings. Table 2 shows the averages of the top fifty batsmen according to the innings in which they scored and Table 3 does the same according to whether their scores were compiled on domestic or foreign pitches. The first innings bias is particularly evident with Sehwag (whose first innings average was thrice his second innings average), Kambli and Ponsford (first innings average was more than twice their second innings average), Worrell, Waugh, and Lara (first innings average was nearly than twice their second innings averages). The best "second innings" batsmen were Davis (second innings average was 27% higher than his first innings average), Border (15% higher), Flower (14% higher), Kallis (13% higher). At the top of the batting averages, Bradman, performed marginally better in the second innings (7% higher) but displayed a high degree of consistency of performance across both innings.

Another factor that may impact upon individual scores, and collectively, upon their average is whether a batsman is playing at home or overseas: some players make better tourists than others as evidenced by the fact that the home averages of some players are considerably higher than their average score on foreign pitches and, of course, vice-versa.¹⁸ Table 3 shows that some of the top fifty batsmen fared better abroad than at home (Border, Dravid, Hammond, Hobbs, Kambli and Waugh), while others did noticeably better at home (Sobers, Jardine, Lara, Miandad and Weekes). The reasons for this are complex and relate both to individual responses to changed physical conditions such as climate and facilities but also to psychological factors. It should be remembered that, unlike many other sporting contests, Test match cricket takes place over an extended time period with players often separated for long periods from family and home.¹⁹

Following the earlier discussion, the first and second innings CAA are shown in the last columns of Table 2 and the home and away CAA are shown in the last columns of Table 3. Table 2 shows that, in its second innings, the "Bradman machine" would have scored 68 runs compared to its first-innings output of 46 runs; when set to work on foreign pitches, it would have produced 53 runs compared to its domestic output of 54 runs.

¹⁸ The notable exception here is F.S. Jackson who never played test cricket outside of the UK.

¹⁹ For a discussion of the issues that arise see Waugh (2006) and for more general discussion on the role of psychological factors in sport see Syer and Connolly (1984) and Rushall (1995).

Table 3
Home and Away Certainty Scores for the Top Fifty Batsmen in Test Cricket: 1877-2006

Rank Based on average	Player	Average	Innings	Average Home	Average Away	Certainty Score (CAA) Home	Certainty Score (CAA) Away
1	Bradman, D.G	100	80	98	103	54	53
2	Pollock, R.G	61	41	69	55	37	27
2	Headley, G.A.	61	40	78	47	38	24
2	Sutcliffe, H	61	84	65	56	42	30
3	Paynter, E	59	31	51	67	27	36
3	Barrington, K.F	59	131	51	69	27	43
3	Weekes, E.C	59	81	69	50	39	22
3	Hammond, W.R	58	140	50	66	26	35
4	Dravid, R.S	58	167	50	64	27	35
4	Sobers, G.S	58	160	67	51	38	26
4	Ponting, R.T.	58	166	63	51	35	27
5	Kallis, J.H	57	161	54	59	29	36
5	Hobbs, J.C	57	102	52	60	30	34
5	Walcott, C.L	57	74	70	40	42	19
5	Hutton, L	57	138	58	55	29	36
6	Tendulkar, S.R	56	209	60	54	31	27
7	Tyldesley, G.E	55	20	52	57	29	35
8	Davis, C.A.	54	29	67	30	44	16
8	Kambli, V.G	54	21	47	65	21	26
8	Hayden, M.L	54	141	64	44	34	23
8	Chappell, G.S	54	151	54	53	29	27
8	Nourse, A.D	54	62	52	56	29	30
8	Sehwag, V	54	72	49	57	22	25
9	Lara, B.C	53	216	61	47	30	19
9	Miandad, J	53	189	64	45	37	23
10	Inzamam U.H	52	177	58	48	30	26
10	Ryder, J	52	32	49	58	26	35
10	Flower, A	52	112	52	51	30	28
10	Smith G.C	52	75	49	53	24	25
11	Gavaskar, S.M	51	214	52	50	25	25
11	Waugh, S.R	51	260	47	56	26	31
11	Mohammad, Y	51	108	56	47	30	23
11	Border, A.R	51	265	46	56	26	34
12	Richards, I.V.A	50	182	50	51	25	25
12	Gilchrist, A.C	50	116	48	53	27	27
12	Compton, D.C.S	50	131	60	37	33	18
12	Worrell, F.M.M	49	87	55	45	29	20
13	Mead, C.P	49	26	229	42	195	19
13	Bland, K.C.	49	39	40	57	24	38
13	Mitchell, B	49	80	47	50	30	25
13	Jackson, F.S	49	33	49	0	29	-
14	Khan, Y	48	74	52	47	23	21
14	Harvey, R.N	48	137	45	51	21	26
14	Walters, D.S	48	125	58	40	34	19
14	Ponsford, W.H	48	48	41	62	19	28
14	McCabe, S.J	48	62	42	55	21	28
14	Jardine, D.R	48	33	82	38	60	24
14	Martyn, D.R	48	98	49	47	30	23
14	Dexter, E.R	48	102	43	54	23	28
14	Jayawardene, D.P.	48	123	57	37	30	21

3. Measuring the Value of a Batsman to His Team

Batting averages measure the performance of players in an *absolute* sense, that is without reference to their team's performance. However, given that cricket is a team game, an interesting question – and one that, to the best of our knowledge, has not been investigated – is how batsmen perform *relative* to other team members?²⁰ An important aspect of relative performance is the contribution that individual batsmen make to their team's total. In order to assess this, we computed for each batsman the total number of runs scored in all his innings as a *percentage* of the total number of runs scored by his team in these same innings: on average, the top fifty batsmen, over the course of their careers, contributed 16% to their teams' total of runs.

These percentage contributions are shown in Table 4 for the individual batsmen. In the Test Matches that Bradman played, one-fourth of the Australian team's runs came from his bat; over their careers, Headley and Lara contributed, respectively, 22 and 19 percent to their teams' scores. So, from the perspective of value to their teams, Bradman, Headley, and Lara were the most "valuable" of the world's top fifty Test batsmen; at the other end, Jardine (11 percent), Gilchrist (11 percent), and Ryder (12 percent) were the least valuable (to their teams) of the world's top fifty Test batsmen.²¹ The ranking of the world's top fifty Test batsmen, on the basis of their career *value-to-team* are very different from the ranking based on career averages: Bradman remains the best batsman on either criteria but Lara, who was ranked joint 9th on the basis of average, moves to third spot (just behind Headley) in terms of value-to-team; at the other end of the spectrum, Paynter, who occupied the joint 3rd place on the basis of his average, drops to the joint 8th spot on the basis of his "value-to-team".²²

²⁰ The issue of quantifying the significance of individual performance within a team sport environment has always proven problematic. Clearly, the individual performance is, in some ways, dependent upon interaction with other members of the team. This is particularly true in football codes but even in the essentially individualistic pursuit of test cricket batting, batting "partnerships" have proven to be influential. As well, it can be argued that players benefit from the performance of others, particularly when these players have already built the innings. See, Kahn and Lawrence (1993)

²¹ A.C. Gilchrist is a special case. He is essentially a lower order batsman (batting at number 7) in Test cricket and, as such, is more subject to the vagaries of "needs batting", early declarations and unreliable batting partners than the other 49 batsmen who all bat at number 6 (S.W. Waugh) or above. The strength of the Australian "tail" normally starting with A.C. Gilchrist is credited with giving the team a competitive edge in recent years.

²² It needs emphasising, particularly in the case of Paynter, that value-to-team is defined in terms of a batsman's contribution to the team score over his career: nobody who recalls the Brisbane Test of the infamous 1932-33 "bodyline" tour, when Paynter, after the spending the night in hospital, came in to make 83, can have any doubt as to his value to his side in that Test Match.

Table 4
Contributions to Their Team Score by the Top 50 Batsmen in Test Cricket: 1877-2006

Rank Based on average	Player	Average	Innings	Percentage Career Contribution to Team Score	Rank based on Career Contribution to Team Score	Difference between column 1 and column 5 ranks
1	Bradman, D.G.	100	80	25	1	0
2	Pollock, R.G.	61	41	17	5	-3
2	Headley, G.A.	61	40	22	2	0
2	Sutcliffe, H.	61	84	17	5	-3
3	Paynter, E.	59	31	14	8	-5
3	Barrington, K.F.	59	131	17	5	-2
3	Weekes, E.C.	59	81	18	4	-1
3	Hammond, W.R.	58	140	17	5	-2
4	Dravid, R.S.	58	167	17	5	-1
4	Sobers, G.S.	58	160	16	6	-2
4	Ponting, R.T.	58	166	14	8	-4
5	Kallis, J.H.	57	161	15	7	-2
5	Hobbs, J.C.	57	102	18	4	+1
5	Walcott, C.L.	57	74	16	6	-1
5	Hutton, L.	57	138	18	4	+1
6	Tendulkar, S.R.	56	209	16	6	0
7	Tyldesley, G.E.	55	20	17	5	+2
8	Davis, CA	54	29	16	6	+2
8	Kambli, V.G.	54	21	14	8	0
8	Hayden, M.L.	54	141	15	7	+1
8	Chappell, G.S.	54	151	16	6	+2
8	Nourse, A.D.	54	62	18	4	+4
8	Sehwag, V.	54	72	16	6	+2
9	Lara, B.C.	53	216	19	3	+6
9	Miandad, J.	53	189	16	6	+3
10	Inzamam U.H.	52	177	15	7	+3
10	Ryder, J.	52	32	12	10	0
10	Flower, A.	52	112	17	5	+5
10	Smith G.C.	52	75	15	7	+3
11	Gavaskar, S.M.	51	214	17	5	+6
11	Waugh, S.R.	51	260	13	9	+2
11	Mohammad, Y.	51	108	15	7	+4
11	Border, A.R.	51	265	14	8	+3
12	Richards, I.V.A.	50	182	15	7	+5
12	Gilchrist, A.C.	50	116	11	11	+1
12	Compton, D.C.S.	50	131	16	6	+6
12	Worrell, F.M.M.	49	87	15	7	+5
13	Mead, C.P.	49	26	15	7	+6
13	Bland, K.C.	49	39	15	7	+6
13	Mitchell, B.	49	80	17	5	+8
13	Jackson, F.S.	49	33	16	6	+7
14	Khan, Y.	48	74	15	7	+7
14	Harvey, R.N.	48	137	17	5	+9
14	Walters, D.S.	48	125	15	7	+7
14	Ponsford, W.H.	48	48	13	9	+5
14	McCabe, S.J.	48	62	14	8	+6
14	Jardine, D.R.	48	33	11	11	+3
14	Martyn, D.R.	48	98	12	10	+4
14	Dexter, E.R.	48	102	14	8	+6
14	Jayawardene, D.P.	48	123	15	7	+7

Another way of assessing the value of a batsman to his team is to ask how many *additional* runs a batsman would make if the rest of the team made *another* 100 runs. In order to answer this question we estimated, for every one of the top fifty Test Match batsmen, the regression equation:

$$R_i = \alpha S_i + \varepsilon_i$$

where: R_i is the score of the batsman and S_i are the runs scored by the other team members (team score less batsman's score) in his i^{th} innings ($i=1 \dots N$). If $\hat{\alpha}$ is the estimate of α , then, on average, for every additional 100 runs scored by the other team members in an innings, the batsman in question would score another $\hat{\alpha}$ runs.

Table 5 shows the values of $\hat{\alpha}$ for the various batsmen. Again the top three batsmen are Bradman, Headley, and Lara: for every 100 additional runs scored by his team mates, Bradman would have scored another 31 runs and Headley and Lara would have scored another 20 runs. At the other end of the scale, the least valuable batsmen to their teams were Ryder and Jardine (11 runs for every 100 additional runs scored by their team mates).

The preceding analysis raises a more general question: should the runs made by a batsman in his different innings be valued differently? Arguably, a century, when the team score is 600, has less value compared to a half-century in an innings total of, say, 200. But, this raises a further question: if runs made in different innings are to be evaluated differently, how should this differential valuation be carried out? We now turn to this issue.

Suppose a batsman plays N innings (indexed, $i=1..N$). If $C = \sum_{i=1}^N R_i$ is his career total of runs, his career average is $\mu = C / M$, where $M (\leq N)$ is the number of his "completed" innings. We define a batsman's *value adjusted average*, denoted Ω , as:

$$\Omega = \mu + \theta$$

where θ is the amount by which his career average is adjusted (either positively or negatively) to reflect his value to the team: we refer to θ as his *value added adjustment*.

Table 5
The Relation between Individual and the "Rest of Team" Scores for the Top 50 Batsmen in Test Cricket: 1877-2006

Rank Based on average	Player	Average	Innings	$\hat{\alpha}^*$	Rank based on $\hat{\alpha}$	Rank based on Career Contribution to Team Score
1	Bradman, D.G.	100	80	31	1	1
2	Pollock, R.G.	61	41	17	5	5
2	Headley, G.A.	61	40	20	2	2
2	Sutcliffe, H.	61	84	17	5	5
3	Paynter, E.	59	31	13	9	8
3	Barrington, K.F.	59	131	19	3	5
3	Weekes, E.C.	59	81	19	3	4
3	Hammond, W.R.	58	140	17	5	5
4	Dravid, R.S.	58	167	18	4	5
4	Sobers, G.S.	58	160	17	5	6
4	Ponting, R.T.	58	166	14	8	8
5	Kallis, J.H.	57	161	16	6	7
5	Hobbs, J.C.	57	102	19	3	4
5	Walcott, C.L.	57	74	16	6	6
5	Hutton, L.	57	138	19	3	4
6	Tendulkar, S.R.	56	209	17	5	6
7	Tyldesley, G.E.	55	20	18	4	5
8	Davis, CA	54	29	18	4	6
8	Kambli, V.G.	54	21	15	7	8
8	Hayden, M.L.	54	141	14	8	7
8	Chappell, G.S.	54	151	16	6	6
8	Nourse, A.D.	54	62	20	2	4
8	Sehwag, V.	54	72	14	8	6
9	Lara, B.C.	53	216	20	2	3
9	Miandad, J.	53	189	18	4	6
10	Inzamam U.H.	52	177	16	6	7
10	Ryder, J.	52	32	11	11	10
10	Flower, A.	52	112	19	3	5
10	Smith G.C.	52	75	14	8	7
11	Gavaskar, S.M.	51	214	17	5	5
11	Waugh, S.R.	51	260	14	8	9
11	Mohammad, Y.	51	108	15	7	7
11	Border, A.R.	51	265	15	7	8
12	Richards, I.V.A.	50	182	15	7	7
12	Gilchrist, A.C.	50	116	12	10	11
12	Compton, D.C.S.	50	131	15	7	6
12	Worrell, F.M.M.	49	87	17	5	7
13	Mead, C.P.	49	26	15	7	7
13	Bland, K.C.	49	39	13	9	7
13	Mitchell, B.	49	80	17	5	5
13	Jackson, F.S.	49	33	19	3	6
14	Khan, Y.	48	74	16	6	7
14	Harvey, R.N.	48	137	18	4	5
14	Walters, D.S.	48	125	16	6	7
14	Ponsford, W.H.	48	48	14	8	9
14	McCabe, S.J.	48	62	12	10	8
14	Jardine, D.R.	48	33	11	11	11
14	Martyn, D.R.	48	98	12	10	10
14	Dexter, E.R.	48	102	16	6	8
14	Jayawardene, D.P.	48	123	15	7	7

*For every 100 runs scored by the rest of team, the named batsman would score $\hat{\alpha}$ runs

Let v_i represent the value (per run) associated with the R_i runs scored in innings i ($i=1..N$). Hereafter, v_i is referred to as the *unit value* associated with the i^{th} innings.²³ Then the *value added adjustment*, θ , is defined as the weighted sum of the runs scored in the various innings, the weights being the unit values associated with the innings:

$$\theta = \left(\sum_{i=1}^N v_i R_i \right) / M$$

If T_i denotes the team score in the i^{th} innings of a batsman's career, $p_i = R_i / T_i$ is his proportionate contribution to the team score, $0 \leq p_i \leq 1$. Suppose that z represents a "threshold" contribution on the basis of which we define:

$$v_i = \frac{p_i - z}{z}$$

The unit-values, v_i , defined above, place the value of runs in the context of "team contribution". They are such that:

$$v_i > 0 \text{ if } p_i > z, \quad v_i < 0 \text{ if } p_i < z, \quad \text{and } v_i = 0 \text{ if } p_i = z .$$

In other words, if the batsman's contribution to the team score in any innings exceeds/ is less than/ equals the threshold contribution, then the unit value attached to the runs made in that innings is positive/negative/zero respectively. In order to make the results comparable across the batsmen, we chose the *same* threshold, z , for *all* the batsmen. For example, z was taken as the average value of the p_i for Bradman: $z = \sum_{i=1}^N p_i / N = 0.22$.²⁴

²³ If $v_j > v_k$, then the R_j runs scored in innings j would be valued more highly than the R_k runs scored in innings k

²⁴ In one sense the choice of Bradman as the default standard is arbitrary but is justified in much the same way as best outcome in Data Envelope Analysis (DEA) is used to rank the efficiency of all other parts of the Decision Making Unit (DMU) and is often used in analysis of the efficiency of sporting teams by comparing the most successful team with the others in the competition, see (Haas (2004))

Table 6
Ranking by Average, Value-Adjusted Average, and Value-Added Adjustment of the Top Fifty Batsmen in Test Cricket: 1877-2006

Rank Based on average	Player	Average	Value added adjustment (θ)	Value adjusted average (Ω)	Rank based on Ω	Rank based on θ	Rank based on Career Contribution to Team Score
1	Bradman, D.G.	100	65	165	1	1	1
2	Pollock, R.G.	61	24	85	4	5	5
2	Headley, G.A.	61	44	105	2	2	2
2	Sutcliffe, H.	61	15	76	7	12	5
3	Paynter, E.	59	13	72	9	14	8
3	Barrington, K.F.	59	12	70	11	15	5
3	Weekes, E.C.	59	29	88	3	3	4
3	Hammond, W.R.	58	23	81	5	6	5
4	Dravid, R.S.	58	13	71	10	14	5
4	Sobers, G.S.	58	12	69	12	15	6
4	Ponting, R.T.	58	11	68	13	16	8
5	Kallis, J.H.	57	9	66	15	18	7
5	Hobbs, J.C.	57	18	75	8	9	4
5	Walcott, C.L.	57	13	70	11	14	6
5	Hutton, L.	57	24	81	5	5	4
6	Tendulkar, S.R.	56	14	70	11	13	6
7	Tyldesley, G.E.	55	11	66	15	16	5
8	Davis, CA	54	3	57	22	23	6
8	Kambli, V.G.	54	15	70	11	12	8
8	Hayden, M.L.	54	16	70	11	11	7
8	Chappell, G.S.	54	14	68	13	13	6
8	Nourse, A.D.	54	17	71	10	10	4
8	Sehwag, V.	54	26	79	6	4	6
9	Lara, B.C.	53	29	83	4	3	3
9	Miandad, J.	53	11	63	16	16	6
10	Inzamam U.H.	52	10	62	17	17	7
10	Ryder, J.	52	5	57	22	21	10
10	Flower, A.	52	15	67	14	12	5
10	Smith G.C.	52	19	70	7	8	7
11	Gavaskar, S.M.	51	18	69	12	9	5
11	Waugh, S.R.	51	1	52	24	24	9
11	Mohammad, Y.	51	10	61	18	17	7
11	Border, A.R.	51	5	55	22	21	8
12	Richards, I.V.A.	50	11	61	18	16	7
12	Gilchrist, A.C.	50	-2	48	25	25	11
12	Compton, D.C.S.	50	11	61	18	16	6
12	Worrell, F.M.M.	49	10	59	20	17	7
13	Mead, C.P.	49	14	63	16	13	7
13	Bland, K.C.	49	20	69	12	7	7
13	Mitchell, B.	49	14	63	16	13	5
13	Jackson, F.S.	49	11	60	19	16	6
14	Khan, Y.	48	10	58	21	17	7
14	Harvey, R.N.	48	14	62	17	13	5
14	Walters, D.S.	48	7	55	23	20	7
14	Ponsford, W.H.	48	9	57	22	18	9
14	McCabe, S.J.	48	14	62	17	13	8
14	Jardine, D.R.	48	-8	40	27	27	11
14	Martyn, D.R.	48	-3	45	26	26	10
14	Dexter, E.R.	48	4	52	24	22	8
14	Jayawardene, D.P.	48	7	55	23	20	7

Table 6 shows the values of μ , θ , and Ω for the top fifty batsmen. In terms of θ , the value added adjustment, the top three batsmen were Bradman ($\theta = 65$), Headley ($\theta = 44$), and B.C. Lara ($\theta = 29$) and the lowest ranked three batsmen were D.J. Jardine ($\theta = -8$), Martyn ($\theta = -3$), and Gilchrist ($\theta = -2$). The value adjusted average, Ω , is obtained by adding the value added adjustment, θ to the conventional average, μ . On the basis of the value adjusted average, Ω , the top three batsmen were: Bradman ($\Omega = 165$), Headley ($\Omega = 105$), and Weekes ($\Omega = 88$). Lara, who was third on the θ ranking, is fifth on the Ω ranking ($\Omega = 83$); Pollock, who was seventh on the θ ranking, is fourth on the Ω ranking ($\Omega = 85$). At the other end of spectrum, Jardine ($\Omega = 40$), Martyn ($\Omega = 45$), and Gilchrist ($\Omega = 48$) continued to occupy the last three places.

4. Conclusions

Implicit in this paper was the question: was Bradman the greatest Test batsman ever? In the sixty years since he retired, the number of changes that have occurred in Test cricket - *inter alia* increases in the number of Test playing nations, improvements in the technology associated with the game, and the frequency of Test matches - have meant that the Test averages were the only practicable means left of comparing batsmen across time. However, the interpretation of Test averages is surrounded by difficulties. This paper suggested two ways by which the assessment of batsmen might be extended while remaining within the conceptual framework of the "batting average": first, by taking account of their career consistency and, second, by taking account of their career team contribution.

In proposing these extensions, one of our aims was to eliminate any element of subjectivity from the new measures. For example, a particular innings by a batsman may have had special value to his team because it was played in difficult circumstances – who can forget Paynter's innings of 83 in the Brisbane ("Paynter's") Test of 1932-33? Other examples of such "great" innings will be readily recalled by other cricketing enthusiasts. We did not make any attempt to adjust for such special circumstances for, to do so, would have been to rob the assessment of its objectivity.

Nor did we, in arriving at our assessment of the world's top fifty batsmen, make any attempt to allow for the quality of the opposition against which they played. There has, arguably rarely been a fiercer bowling attack than Jardine's body-line team and, in this context, McCabe's innings of 187 at Sydney in December 1932 – hailed by Bradman as the greatest innings he had ever seen – must mock his lowly position in the rankings (joint 14th). Equally, runs scored

against the West Indian bowling quartet of Holding, Garner, Marshall, and Roberts must have special significance compared to runs amassed against Bangladesh or Zimbabwe. In any heavenly judgement of batsmen these, and many more criteria, will all be used to arrive at a final ranking of batsmen. But, till then, this paper offers a modest proposal for refining rankings based on batting averages.²⁵ In so doing, one awe-inspiring fact stands out: whatever, the criterion used for ranking batsmen, Sir Donald Bradman remains *il capo dei capi*.

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²⁵ However, it should be pointed out, that the International Cricket Commission (ICC) produce rankings (under the auspices of Deloitte, Coopers & Lybrand, LG, and now Reliance mobile) which take account of several of these factors: runs scored; quality of opposition; the level of run scoring in the match; completed or not out innings; the match result. These are fed into a pre-programmed formula which spews out the results. However, the opacity of the ICC's formula makes the methodology difficult to comprehend. By contrast, the more modest extensions proposed here are, we believe, both novel and transparent.

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