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Comparing Multi Criteria Decision Making Methods by Evaluation of Batter's Current Performance in T20 Internationals

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Abstract- Cricket analytics is the field of collecting cricket data and analysing it which can be used to improve player's or team's performance. Here in this paper, Multi Criteria Decision Making methods are applied and batters playing T20 Internationals for past ten years are ranked according to their current performances. These rankings are useful not only to predict best batters but also to guide other batters to adapt their techniques. Criteria used are Runs Per Innings (RPI), Strike Rate (SR), Balls Per Boundary (BPB) and Dot Percentage. Analytic Hierarchy Process (AHP) is used to give weights to these criteria and Weighted Sum Model (WSM), Weighted Product Model (WPM) and the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) are used to rank the batters. Finally, these methods are compared to check robustness of the output based on the concept of Sensitivity Analysis.

Index Terms- AHP, Rankings, TOPSIS, T20I

I. INTRODUCTION

Cricket is a game of numbers. In Cricket, team selection by the management, shot selection by the batter, field setting by the bowler or captain are some examples of decisions need to make. Decision making is the process of selecting the best possible alternative from a group of alternatives based on a set of rules framed by us. Multiple times this decision is not based on single criterion. Thus, we need to consider multiple criteria which gives rise to Multi Criteria Decision Making (MCDM) methods. Benjamin Franklin, the American political philosopher used this type of MCDM technique to state his decisions on an important issue for the first time, but he did not used this term. Frank Ramsey proposed a method for developing a consistent theory that distinguishes between beliefs and preferences. [1] Ward Edwards discussed how people make decisions and how they may make better ones. Herbert A. Simon wrote about decision theory in his articles. He gave idea about aspiration level. Charnes, Cooper and Fergusson invented idea of goal programming based on optimization using multiple objectives. Bernard Roy proposed ELECTRE method. Bruno Contini and Stanley Zionts proposed a negotiable model on multiple objectives for restricted bargaining. Ronald Howard studied about decision phenomenon using a coin tossing problem. Stanley Zionts and Jyrki Wallenius stated a mathematical method for solving multi criteria problem having single decision maker. Ralph Keeney[2] and Howard Raiffa wrote a reference book. Analytic Hierarchy Process was developed by Thomas L. Saaty Hwang and Yoon developed TOPSIS method. Further developements were made by Yoon and Lai, Liu and Hwang Triantaphyllou wrote a book on multi criteria decision making methods. Kashid, Mehta and Basotia developed a AHP-TOPSIS model for selection of players in IPL. Dey, Ghosh and Mondal proposed MCDM approach to evaluate bowlers' performance. Saqlain et al. predicted cricket World Cup winner using TOPSIS method. Vassoney et. al proposed a method for comparing some MCDM methods.

In this paper different multi criteria decision making methods are studied in section 2. Section 3 gives information about sensitivity analysis. A case study of T20 International matches is considered in section 4, which gives details about criteria and alternatives used. Finally, section 5 concludes the paper.[3]

II. MCDM METHODS

Multi Criteria Decision Making (MCDM) is an approach to find optimal solution from set of possible solutions based upon some criteria. Here mainly we require three terminologies, Alternatives: These are the available options or possible solutions, Criteria: These are some assumed parameters which affect selection of the best alternative, Weights: These[6] are the values of importance given to each criterion. The output obtained may vary by changing weights of criteria.

Steps in MCDM methods are:

1. Identifying the decision
2. Identifying the criteria and set of alternatives
3. Determining the weights to criteria
4. Ranking the alternatives

A. Method to determine the weights of criteria

Analytic Hierarchy Process (AHP) was developed by T. L. Saaty in 1970s. AHP works on Psychology and Mathematics to make complex decisions. We use AHP to decide weights to criteria. For this, we need to build pairwise comparison matrix which is a square matrix with criteria as rows and columns.

$$P = \left[p_{ij} \right]_{n \times n} \qquad i, j = 1, 2, \ldots n \tag{1}$$

where n: number of criteria,
Saaty scale [11] is used to construct matrix P.

Table I: Saaty's scale

Scales	Degree of preference
1	Equally
3	Moderately
5	Strongly
7	Very strongly
9	Extremely
2,4,6,8	Intermediate values
Reciprocals	Opposites

Steps to perform AHP:
Step 1: Normalize pairwise comparison matrix A.

$$A = \left[\frac{p_{ij}}{\sum_{i=1}^{n} p_{ij}} \right]_{n \times n} \tag{2}$$

where $i,j = 1,2,\ldots n$
Step 2: Assign weights.

$$W_j = \sum_{j=1}^{n} p_{ij} \tag{3}$$

where $i,j = 1,2,\ldots n$

Before considering these weights as final priorities, in order to find the optimal solution fast, we need to check consistency of pairwise comparison matrix.

Step 1: Obtain weighted sum matrix.

$$S^* = \left[\sum_{j=1}^{n} a_{ij} \cdot w_j \right]_{n \times 1} \tag{4}$$

where a_{ij} and w_j are components of A and W_j respectively, $i,j = 1,2,\ldots n$

Step 2: Obtain consistency vector.

$$CV^* = \left[\frac{\sum_{j=1}^{n} a_{ij} \cdot w_j}{w_j} \right]_{n \times 1} \tag{5}$$

where $i,j = 1,2,\ldots n$

Step 3: Calculate maximum eigenvalue.

$$\lambda_{\max} = \sum_{i=1}^{n} CV^*_{n \times 1} \tag{6}$$

Step 4: Find consistency index.

$$CI = \frac{\lambda_{\max} - n}{n - 1} \tag{7}$$

Step 5: Calculate consistency ratio.

$$CR = \frac{CI}{RCI} \tag{8}$$

RCI for different values of n is given by Saaty as follows:

Table II: Random Consistency Index (RCI)

n	RCI
1	0
2	0
3	0.58
4	0.9
5	1.12
6	1.24
7	1.32
8	1.41
9	1.45
10	1.49

If value of $CR \leq 0.1$ then matrix P in eq (1) is consistent and weights obtained in eq (3) are acceptable [11].

B. Methods to rank the alternatives

Decision matrix is a matrix with alternatives as rows and criteria as columns. The representation of decision matrix is as follows:

$$D = \left[d_{ij} \right]_{m \times n} \tag{9}$$

where m: no. of alternatives, n: no. of criteria, $i = 1,2,..m, j = 1,2,..n$

a. Weighted Sum Model (WSM)

Step 1: Normalization of decision matrix.

$$D' = [d'_{ij}]_{m \times n} \tag{10}$$

where for benefit criteria: $d'_{ij} = \frac{d_{ij}}{\max_j d_{ij}}$, for loss criteria: $d'_{ij} = 1 - \frac{d_{ij}}{\max_j d_{ij}}$

$i = 1,2,..m, j = 1,2,..n$

Step 2: Calculate row-wise WSM score.

$$Score_{WSM} = \sum_{j=1}^{n} d'_{ij} \cdot w_j \tag{11}$$

where $i = 1,2,..m$, $j = 1,2,..n$

Step 3: Rank the alternatives according to maximum WSM score.

b. Weighted Product Model (WPM)

Step 1: Construction and normalization of decision matrix. Refer (10)

Step 2: Calculate row-wise WPM score.

$$Score_{WPM} = \prod_{j=1}^{n} d_{ij}'^{\,w_j} \quad (12)$$

where $i = 1,2,..m$, $j = 1, 2,..n$

Step 3: Rank the alternatives according to maximum WPM score.

C. The Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS)

TOPSIS is a distance based method. It is built on the idea that the greatest solution is closest to the ideal best alternative and farthest away from the ideal worst alternative. The ideal best alternative has the best attribute value, whereas the ideal worst alternative has the worst attribute value.

Step 1: Construct normalized decision matrix.

$$X = \left[x_{ij}\right]_{m\times n} \quad (13)$$

where $$x_{ij} = \frac{d_{ij}}{\sqrt{\sum_{i=1}^{n} d_{ij}^2}}$$

Step 2: Construct weighted normalized decision matrix.

$$W = \left[w_{ij}\right]_{m\times n} \quad (14)$$

where $$w_{ij} = w_j \cdot x_{ij}$$

Step 3: Determine ideal best and ideal worst solution. For benefit criteria

$$V^+, V^- = (\max_j w_{ij}), (\min_j w_{ij}) \quad (15)$$

where $i = 1,2,...m$, $j=1,2,...n$

where V^+: ideal best solution, V^-: ideal worst solution and vice versa for loss criteria

Step 4: Calculate separation measure.

$$S_i^+ = \sqrt{\sum_{j=1}^{n} (w_{ij} - V^+)^2} \quad (17)$$

$$S_i^- = \sqrt{\sum_{j=1}^{n} (w_{ij} - V^-)^2} \quad (18)$$

where $i = 1, 2,...m$, $j= 1, 2, ...n$

Step 5: Calculate relation closeness to ideal solution (TOPSIS score).

$$Score_{TOPSIS} = \frac{S_i^-}{S_i^+ + S_i^-} \quad (19)$$

Step 6: Rank the alternatives according to maximum TOPSIS score.

III. SENSITIVITY ANALYSIS

Under a set of assumptions, sensitivity analysis determines how independent variables affect dependent variables. It is used to check quality of the decision. That means we will check whether output will change or not by changing input little bit. Here concept of sensitivity analysis will be used to compare MCDM methods.[4]

IV. A CASE STUDY

A. Dataset

The ball-by-ball dataset we are considering here is taken from cricsheet.org. The dataset considered here is consists of all T20 Internationals [6] played till date. Out of which we are going to consider matches only after 2011 i.e., matches played in last decade. Since not all the teams who played T20I are consistent, we will consider only top 9 consistent teams namely India, Australia, South Africa, England, Pakistan, Sri Lanka, West [5] Indies, New Zealand and Bangladesh. Obviously, not all the batters batted in these years are consistently performing well, but in order to recognize top batters we should consider only those who are consistent. This is achieved by filtering the data by number of innings played by a batter. Here a batter is suitable if he has played innings more than or equal to 60. Total number of batters considered is 21.

B. Performing MCDM

Here these 21 players are alternatives and criteria are Runs Per Innings (RPI), Strike Rate (SR), Balls Per Boundary (BPB) and Dot Percentage, where RPI, SR are benefit criteria and BPB, Dot Percentage are loss criteria.

a. Pairwise Comparison Matrix

Table III: Pairwise Comparison Matrix

	RPI	SR	BPB	Dot P
Weights	0.13	0.25	0.49	0.14
RPI	1	0.25	0.2	2
SR	4	1	0.5	1
BPB	5	2	1	4
Dot P	0.5	1	0.25	1

CR = 0.0007

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b. Decision Matrix

Table IV: Decision Matrix

	Striker	RPI	SR	BPB	Dot
1	AJ Finch	31.358025	143.746463	4.814714	0.392190
2	Babar Azam	38.529412	125.478927	6.692308	0.313697
3	C Munro	28.344262	152.469136	4.725000	0.365079
4	DA Miller	21.986301	139.686684	6.455056	0.291558
5	EJG Morgan	21.602273	131.739432	6.24753	0.370755
6	GJ Maxwell	26.342857	149.070331	5.008097	0.358124
7	JC Buttler	27.282051	136.936937	5.692308	0.370013
8	KA Pollard	21.316667	130.777096	6.229299	0.415133
9	KS Williamson	28.222222	122.631261	6.628000	0.361200
10	MJ Guptill	32.494118	136.597428	5.265625	0.407023
11	Mahmudullah	20.766667	118.591371	7.687805	0.373731
12	Mohammad Hafeez	23.630952	120.742092	6.523810	0.409367
13	Mushfiqur Rahim	17.888889	114.184397	7.726027	0.367021
14	NLTC Parera	15.661290	140.928882	5.496378	0.365747
15	Q de Kock	30.450000	131.344357	5.476378	0.399712
16	RG Sharma	30.402174	139.780110	5.183938	0.380310
17	S Dhawan	26.984615	123.001403	5.917012	0.41238
18	Shakib Al Hasan	22.397260	119.517544	6.640777	0.377924
19	Shoaib Malik	23.53333	128.270349	6.984772	0.318488
20	Soumya Sarkar	17.476923	117.355372	6.205128	0.472107
21	V Kohli	38.365854	124.617030	6.350543	0.295250

c. Need Of Performing MCDM

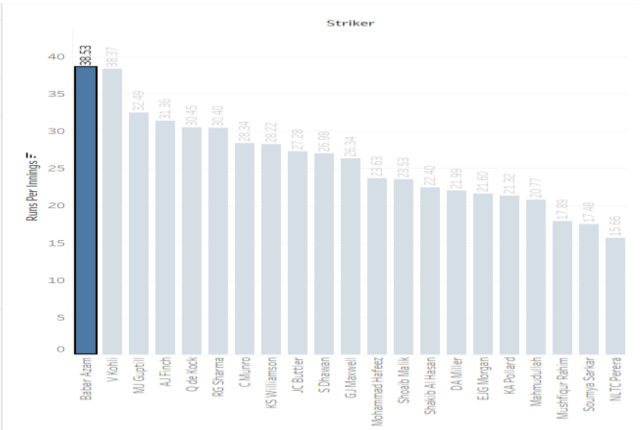

Figure 1: Graph of RPI v/s Striker

Fig. 1 shows that Babar Azam has highest runs per innings that is nearly 39.

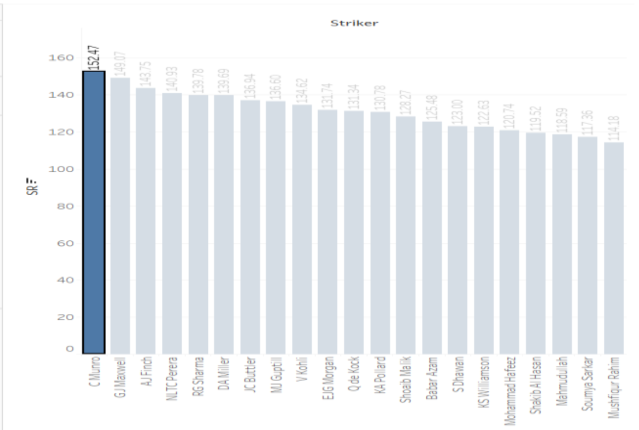

Figure 2: Graph of SR v/s Striker

Fig. 2 shows that C Munro has highest strike rate of 152.47.

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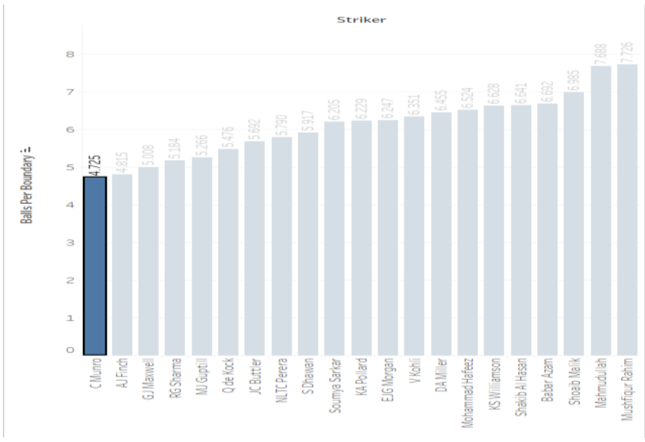

Figure 3: Graph of BPB v/s Striker

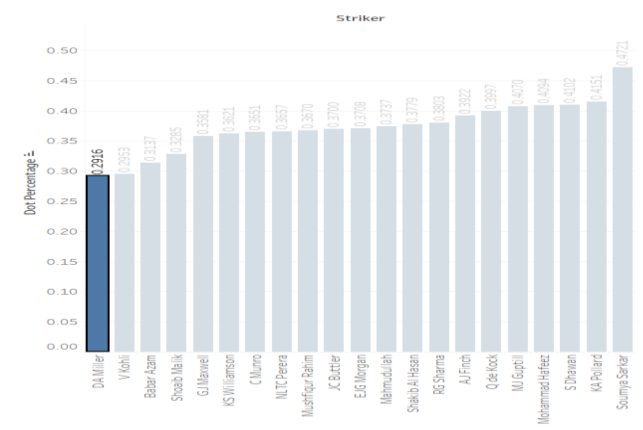

Figure 4: Graph of Dot Percentage v/s Striker

Fig. 3 shows that C Munro has taken less balls to score a boundary that is nearly 5 balls.

Fig. 4 shows that D A Miller has lowest dot percentage rate 0.2916.

Thus we can notice that if we consider all the criteria separately, it is difficult for decision maker to decide top batter. Hence MCDM plays very crucial role in this type of situation.

d. Results obtained by MCDM method

Rankings of batters by all three MCDM methods is as follows:

Table V: Batters rankings

Striker	WSM-score	WSM-rank	WPM-score	WPM-rank	TOPSIS-score	TOPSIS-rank
AJ Finch	0.5498	2	0.4637	3	0.8849	3
Babar Azam	0.4483	9	0.3051	13	0.2379	13
C Munro	0.5677	1	0.4911	1	0.9726	1
DA Miller	0.4374	11	0.3283	11	0.6689	6
EJG Morgan	0.4128	13	0.3207	12	0.3192	11
GJ Maxwell	0.5395	3	0.4648	2	0.9442	2
JC Buttler	0.4758	8	0.3906	7	0.5973	8
KA Pollard	0.3982	15	0.2965	14	0.2798	12
KS Williamson	0.3985	14	0.2851	15	0.0828	16
MJ Guptill	0.5089	5	0.4116	5	0.6283	7
Mahmudullah	0.2961	20	0.0516	19	0.0134	19
Mohammad Hafeez	0.3726	17	0.2682	16	0.0416	17
Mushfiqur Rahim	0.2787	21	0.0000	20	0.0003	21
NLTC Parera	0.4382	10	0.3593	9	0.6864	5
Q de Kock	0.4822	7	0.3926	6	0.3699	10
RG Sharma	0.5202	4	0.4376	4	0.7484	4
S Dhawan	0.4258	12	0.3342	10	0.0907	15
Shakib Al Hasan	0.3683	18	0.2674	17	0.0268	18
Shoaib Malik	0.3793	16	0.2411	18	0.1906	14
Soumya Sarkar	0.3478	19	0.0000	21	0.0134	20
V Kohli	0.4898	6	0.3625	8	0.5758	9

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C. Performing Sensitivity Analysis

Here we change weights of criteria to see whether there are any changes in positions of batters. We change weights by 10% i.e., increase benefit criteria weights by 10% and decrease loss criteria weights by 10%.

a. Rankings Comparison by WSM

Table VI: Rankings Comparison by WSM

Striker	Original	wt change 10%	Striker	Original	wt _change 10%
AJ Finch	2	2	Mohammad Hafeez	17	17
Babar Azam	9	9	Mushfiqur Rahim	21	21
C Munro	1	1	NLTC Parera	10	11
DA Miller	11	10	Q de Kock	7	7
EJG Morgan	13	13	RG Sharma	4	4
GJ Maxwell	3	3	S Dhawan	12	12
JC Buttler	8	8	Shakib Al Hasan	18	18
KA Pollard	15	15	Shoaib Malik	16	16
KS Williamson	14	14	Soumya Sarkar	19	19
MJ Guptill	5	5	V Kohli	6	6
Mahmudullah	20	20			

b. Rankings Comparison by WPM

Table VII: Rankings Comparison **by** WPM

Striker	Original	wt change 10%	Striker	Original	wt _change 10%
AJ Finch	3	2	Mohammad Hafeez	16	16
Babar Azam	13	13	Mushfiqur Rahim	20	20
C Munro	1	1	NLTC Parera	9	9
DA Miller	11	11	Q de Kock	6	6
EJG Morgan	12	12	RG Sharma	4	4
GJ Maxwell	2	3	S Dhawan	10	10
JC Buttler	7	7	Shakib Al Hasan	17	17
KA Pollard	14	14	Shoaib Malik	18	18
KS Williamson	15	15	Soumya Sarkar	21	21
MJ Guptill	5	5	V Kohli	8	8
Mahmudullah	19	19			

c. Rankings Comparison by TOPSIS

Table VIII: Rankings Comparison by TOPSIS

Striker	Original	wt change 10%	wt change 70%	Striker	Original	wt change 10%	wt change 70%
AJ Finch	3	3	3	Mohammad Hafeez	17	17	17
Babar Azam	13	13	13	Mushfiqur Rahim	21	21	21
C Munro	1	1	1	NLTC Parera	5	5	5
DA Miller	6	6	6	Q de Kock	10	10	10
EJG Morgan	11	11	11	RG Sharma	4	4	4
GJ Maxwell	2	2	2	S Dhawan	15	15	16
JC Buttler	8	8	8	Shakib Al Hasan	18	18	18
KA Pollard	12	12	12	Shoaib Malik	14	14	14
KS Williamson	16	16	15	Soumya Sarkar	20	20	20
MJ Guptill	7	7	7	V Kohli	9	9	9
Mahmudullah	19	19	19				

V. CONCLUSION

In this paper, we studied different MCDM methods and got the batters rankings based on this. By all the three methods, C Munro is currently best T20 player followed by GJ Maxwell and AJ Finch. When we applied sensitivity analysis to compare MCDM methods, we noticed that, when weights are changed by 10%, 19 positions in WSM remain unchanged and 2 positions (10 and 11) interchanged. Similarly, in WPM, 19 positions remain unchanged and 2 positions (2 and 3) interchanged. But in TOPSIS, all positions remain unchanged. After continuing the process of changing weights, we noticed that, when weights are changed by 70% then 2 positions (15 and 16) in TOPSIS interchanged, which is nearly negligible. Hence, we can state that TOPSIS is insensitive to change in weights and thus it is more reliable method.

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