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Comparison of Plithogenic and Neutrosophic Approaches in Decision Making via Best –Worst Method

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Abstract. Decision making is a comprehensive process comprising of uncertainties that shall be handled with the right selection of decision making approaches. Selection of the optimal alternatives and the best criteria is the expected outcome of any decision making strategy. This paper proposes a decision making model based on the plithogenic pythagorean best –worst method which is an extension of the multi-valued neutrosophic approach of BWM. The efficiency of the developed model is determined with the example pertaining to the optimal selection of the teaching methods based on the attribute values or the sub criteria and it is also compared with the neutrosophic approach. In the proposed model plithogenic and pythagorean neutrosophic sets are used for representing the expert's opinion.

Keywords: Multi Criteria Decision Making (MCDM), Best-Worst Method (BWM), Pythagorean Neutrosophic set, Plithogenic set.

INTRODUCTION

To deal with the problems existing in uncertain environment many algorithms were proposed with fuzzy, intutionistic fuzzy and neutrosophic conceptualizations in the last decade. Florentin Smarandache developed the neutrosophic theory and presented the framework of neutrosophic set as a generalization of the fuzzy set and intutionistic fuzzy set [13], later on he proposed a new deliberation of the Plithogenic set, which is a over simplification of a neutrosophic set. Plithogenic sets are distinguished by one or several qualities and each quality have many attributes [1-2]. These sets are being extensively applied in various contexts of decision making at recent times.

Decision-Making (DM) is the outcome of the understanding process in gathering certainty or strategy among many substitutes. The neutral collection process may be combined with the present day DM techniques as the best- worst method (BWM) to solve numerous kinds of problems in various areas of decision-making in our day to day activity. There are many Decision making processes used in various criteria and one of the finest method is BWM. BWM was discussed in fuzzy environment and it is applied in Green Biopharmaceutical Industry, municipal solid waste, supply chain management, optimization technique etc., The consecutive development are intuitionistic fuzzy BWM and neutrosophic BWM. Later it is applied in Plithogenic fuzzy with various fields like IoT based supply chain etc., Jafar Rezaei [4] introduced Best Worst Method (BWM) in a multi-criteria decision-making (MCDM) method. BWM is most important method and which is applied to estimate a set of choices based on criteria. The BWM is foundation of a structured pairwise comparison of the decision criteria. Jafar Rezaei, [4] suggested a relevance of robust optimization method to the latest updated model called BW technique and the effecting robust technique is devised as LPP. Grida [2] have conferred in his exertion on how to make pronouncements of IoT based supply chain problem by means of the best-worst method based on a novel Plithogenic model.

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MCDM replica for the improvisation of airline operational and financial recital has been found out by Pineda. P.J.G.et al. [7]. The effects of one-factor transformations over four interconnected control factors cannot be reviewed by the human brain. Scherz and Vafadarnikjoo [12] have implemented the Multiple Criteria Decision Analysis under prolonged uncertainty in edifice that were applied to individual problems within the turf of extended composition. Solairaju et al,[14] formulated the knowledge organization ploy of renovating fuzzy in neutrosophic values into fuzzy values through appreciation techniques through defuzzyfication. Juan-juan Peng,[5] proposed a technique to resolve MCGDM issues and investigated by pertaining the energy aggregation operators. J.Rezaei [8] found the best alternative by accumulating the weights of diverse sets of location points and alternatives. With the intention of finding the priorities in hierarchical structures Saaty TL [10, 11] employed scaling techniques and he suggested the relevance of analytic hierarchy process to make decisions. Performance evaluation of internet-of things-based supply chains using Fuzzy multicriteria analysis is presented by Wibowo.S, &Grandhi.S [15]. Quality Function Deployment for Selecting Supply Chain Sustainability Metrics by applying A Hybrid Plithogenic Decision-Making Approach is presented by Abdel-Basset & Zaied et al [1].Various researchers like Yager, Abbasov, Zhang and Gou have developed various applications using Plithogenic concepts. Yager .R.R[17] generalized Pythagorean Fuzzy set in MCDM. Zhang, X.L.,[18] Introduced the Extension of TOPSIS to Multicriteria Decision Making with Pythagorean Fuzzy Sets. Nivetha.M and F.Smarandache was proposed a Comparative Analysis of Pythagorean Neutrosophic set and Neutrosophic set in Promthee Plithogenic Pythagorean Hypergraphic approach for selection of smart materials [19].

Nivetha and Sudha [20] developed a best –worst model with multi-valued neutrosophic approach in which the objective of the model is to select the optimal teaching methods based on the criteria of

Learner Centric, Activity Based, Space for Creativity, Interactive and Time Efficiency.

The criteria are more general in nature and these are taken as the attributes, in the proposed model each of the attributes assumes attribute values and they are considered as the sub criteria in the plithogenic model. The alternatives are ranked based on the sub criteria and plithogenic aggregate opinion of the experts with Pythagorean neutrosophic representations.

A decision- making model using BW method has been formulated with Plithogenic Pythagorean neutrosophic fuzzy set. Chapter 1 of this paper structures the preamble and literature study; preliminaries are offered in chapter 2; problem solving in chapter 3, a numerical illustration has been explained to confirm the proposed model in chapter 4. Chapter 5 represents the comparision of Plithogenic Pythagorean neutrosophic and neutrosophic approach; finally the ground work is recapitulated in chapter 6.

PRELIMINARIES

This chapter presents the basic descriptions and procedures employed in this ground work.

Neutrosophic Fuzzy Set

Let U^* be the universal set. A neutrosophic set $A_{NF} \in U^*$ which can be expressed by a membership function (Truth Value) T_{NA}, Indeterminacy membership function I_{NA} and non- membership function (False value) F_{NA} where T_{NA} , I_{NA} and F_{NA} are real set of factors in [0,1]. It is described by $A_{NF} = \{< x, T_{NA} , I_{NA} , F_{NA}>: x \in U^*\}$. There is no constraint on the sum of T_{NA} , I_{NA} , F_{NA}

$$0^- \leq sup T_{NA} + sup\ I_{NA} + sup\ F_{NA} \leq 3^+$$

Plithogenic set

F.Smarandache discovered a new concept of plithogeny, which is a generalization of neutrosophy.

Let U^* be a universal set. Let $P \subseteq U^*$ and is called $P = \{P, A, V, d, c\}$ a Plithogenic set.

Let A be a collection of attributes. For each attribute $a \in A$. Let S_a be the collection of attribute values, such that $V_a \subseteq S_a$. A function $d_a : P \times V_a \in [0,1]$ is known as attribute value appurtenance degree function.

A function $C_a : V_a \times V_a \in [0,1]$ defined by attribute value contradiction (dissimilarity) degree function, and it satisfies the following conditions

i) $C_a(v, v) = 0$, for all $v \in V_a$

ii) $C_a(v_1,v_2) = C_a(v_2,v_1)$ for all $v_1,v_2 \in V_a$

Plithogenic Operators

Let a = (a, b, c) and b = (a_1, b_1, c_1) be two plithogenic sets. Let the plithogenic operations be

i) Plithogenic Intersection

$$(a_i, b_i, c_i) \wedge_p (a_{i1}, b_{i1}, c_{i1}) = \left((a_i \wedge_P a_{i1}), \frac{((b_i \wedge_P b_{i1}) + (b_i V_P b_{i1}))}{2}, (c_i V_P c_{i1})\right), \quad 1 \leq i \leq n.$$

ii) Plithogenic Union

$$(a_i, b_i, c_i) V_p (a_{i1}, b_{i1}, c_{i1}) = \left((a_i V_P a_{i1}), \frac{((b_i \wedge_P b_{i1}) + (b_i V_P b_{i1}))}{2}, (c_i \wedge_P c_{i1})\right), \quad 1 \leq i \leq n.$$

Where

$$a_i \wedge_p a_{i1} = [1 - (v_D, _1)].tnorm(v_D, v_1) + c(v_D, v_1).tconorm(v_D, v_1)$$

$$a_i \vee_p a_{i1} = [1 - c(v_D, v_1)].tconorm(v_D, v_1) + c(v_D, v_1).tnorm(v_D, v_1).$$

tnorm : $a \wedge_F b = ab$,

tconorm : $a \vee_F b = a + b - ab$

iii) Plithogenic complement (negation):

$\neg (a_i, b_i, c_i) = (c_i, b_i, a_i)$, $1 \leq i \leq n$

Pythagorean Neutrosophic set

Let U^* be a universal set. A Pythagorean Neutrosophic set is defined by

$$P_{NF} = \{ u_p(x), w_p(x), v_p(x) / x \in U^* \}$$

Where u(x) is the $u_p(x) : U^* \to [0,1]$, degree of membership (True value) function and $v_p(x) : U^* \to [0,1]$ and v(x) is the degree of non-membership function (Falsity value) & . It satisfies the following condition

$u_p^2 + v_p^2 \leq 1$, for all $x \in U^*$ and

$w_p(x) = \sqrt{1 - u_p^2 - v_p^2}$, for all $x \in U^*$, $w_p(x)$ is called Hesitance of Pythagorean fuzzy set (or) Indeterminacy membership value.

METHODOLOGY

Decision -Matrix

The Pythagorean Neutrosophic fuzzy matrix formulated depends on the decision maker's view with suggestion to the criteria's resolution. The steps below shows the conversion of Pythagorean Neutrosophic fuzzy set in to Pythagorean fuzzy decision- matrix Đ(A_j).

Pythagorean Neutrosophic fuzzy values are formed into a Pythagorean neutrosophic fuzzy decision- matrix having M rows & N columns, such that M Pythagorean neutrosophic fuzzy attributes corresponding to N Pythagorean neutrosophic fuzzy alternatives. There are n number of fuzzy decision matrix Đ(A_j) [j = 1 to n] are considered.

Best- Worst approach

A MCDM technique is based on few alternatives $(\alpha_1, \alpha_{2 \ldots\ldots} \alpha_n)$ and various criteria's $(c_1, c_{2 \ldots\ldots} c_n)$ and each options has a rate in order to every condition $(a_{11}, a_{12}, \ldots \ldots a_{mn})$. The MCDM problem could be expressed as the following matrix:

The MCDM problem is

$$a = \begin{pmatrix} a_{11} & a_{12} \cdots \cdots & a_{1n} \\ a_{21} & a_{22} \cdots \cdots & a_{2n} \\ a_{m1} & a_{m2} \cdots \cdots & a_{mn} \end{pmatrix}$$

formulated to get the best decision with the best value (v_i).

$$v_i = \sum_{j=1}^{n} w_j a_{ij} \quad \text{and } w_j \geq 0 \,,\; \sum_{j=1}^{n} w_j = 1$$

There are 'n' number of methods to find out the total score for each option and the simplest way is to apply an additive weighted value function from the following formula (Keeney &Raiffa,1993)[6]

The best-worst method (BWM)(Rezaei,2015) is applied to determine the weight of each Criterion (w_j) and the BWM was used in many areas and it is based on mutually connections on the basis of decision makers views. Using BWM we can easily calculate the score function for each criterion.

The below procedure is used to determine the optimal weights of each criterion based on BW method.

Step 1.

Decision maker describes a opinion on the basis of decision criteria.

Let us consider the criteria $(c_1, c_{2 \ldots\ldots} c_n)$ that should be used to get a decision.

Step 2.

Identify the best and worst criteria for each method.

Step3.

Determine the Best –to –other vector.

Let it be $A_B = (a_{B1}, a_{B2 \ldots\ldots} a_{Bn})$

On the view of decision maker's choice, select the best criteria's and using (1-9) point scale.

where a_{Bj} denotes the significance of the best criteria's B over criteria's j.

That is $a_{BB} = 1$

Step 4

Decide Others –to –worst vector and it is represented by $A_W = (a_{1w}, a_{2w} \ldots\ldots a_{nw})^T$

Decide the importance of all the criteria over the worst criteria using an integer between 1 and 9. The resulting others-to-Worst vector would be, $A_W = (a_{1w}, a_{2w} \ldots\ldots a_{nw})^T$

Where a_{jw} represents the importance of the criteria j over the worst criteria W.

That is . $a_{ww} = 1$

Step 5

Find the optimal weights $(\omega_1^*, \omega_2^*, \ldots\ldots \omega_n^*)$ The optimal weight for the criteria is the one here, for each pair of ω_B/ω_j *and* ω_j/ω_w. Then $\omega_B/\omega_j = a_{Bj}$ and $\omega_j/\omega_w = a_{jw}$.

To satisfy the following conditions for all j, we should find a solution where the maximum absolute differences for all j is minimized, $\left|\frac{\omega_B}{\omega_j} - a_{Bj}\right|$ and $\left|\frac{\omega_j}{\omega_w} - a_{jw}\right|$ which is transferred to the below LPP model,

$$\min \max_j \left\{ \left|\frac{\omega_B}{\omega_j} - a_{Bj}\right|, \left|\frac{\omega_j}{\omega_w} - a_{jw}\right| \right\}$$

$$\text{s.t} \quad \sum_{j=1}^{n} \omega_j = 1 \qquad \omega_j \geq 0, \text{ for all j} \qquad (1)$$

Model (1) is equivalent to the following model:

$$\text{Min } \psi$$

$$\text{s.t} \quad \left|\frac{\omega_B}{\omega_j} - a_{Bj}\right| \leq \psi \text{, for all j}$$

$$\left|\frac{\omega_j}{\omega_w} - a_{jw}\right| \leq \psi \text{ for all j}$$

$$\sum_{j=1}^{n} \omega_j = 1 \qquad (2)$$

$$\omega_j \geq 0, \text{ for all j}$$

Model (2), by $(\omega_1^*, \omega_2^*, \ldots\ldots \omega_n^*)$ solving gives the optimal weights and ψ^* .

From the Table 3.3, the feasibility of the values are checked by determining consistency ratio

$$\text{Consistency Ratio} = \frac{\psi^*}{\text{consistency index}}$$

TABLE 1

Consistency index (CI) table

a_{Bw}	1	2	3	4	5	6	7	8	9
Consistency index (max ψ)	0.00	0.44	1.00	1.63	2.30	3.00	3.73	4.47	5.23

NUMERICAL EXAMPLE

Learner Centric, Activity Based, Space for Creativity, Interactive and Time Efficiency.

The various parameters of Teaching & Learning process are discussed. In this problem Three Decision Makers were give their opinions based on their experience. The parameters are as follows,

Each parameter can be divided in to several attributes and the various methods are M_1, M_2, M_3, M_4, M_5.

TABLE 2. Managerial Decision making Using BWM

S.No	Criteria	C	Sub-Criteria
1	Learner centric	L_1	Collaborative
		L_2	Reflective
		L_3	Inquiry-based
		L_4	Facilitate self-learning
		L_5	Engaging
2	Activity Based	A_1	Active involvement
		A_2	Instructive
		A_3	Motivative
		A_4	Participative
3	Space for Creativity	S_1	Receptive
		S_2	Proactive
		S_3	Flexible
4	Interactive	I_1	Reciprocative
		I_2	Stimulative
		I_3	Effective
5	Time Efficiency	T_1	Comprehensive
		T_2	Continuous
		T_3	Systematic

TABLE 3. Pythagorean Neutrosophic measure for decision matrix

Linguistic variable	Pythagorean Neutrosophic fuzzy number
Very Highly Significant (VHS)	(0.9, 0.3,0.1)
Highly Significant (HS)	(0.8, 0.2, 0.1)
Moderately Significant (MS)	(0.7, 0.2, 0)
Highly Insignificant (HIS)	(0.5, 0.2, 0.1)
Very Highly Insignificant (VHIS)	(0.1, 0.1,0)

TABLE 4. The Plithogenic representation of Experts opinion

Criteria/Experts(E)	C	**E_1**	**E_2**	**E_3**
Learner Centric	L_1	VHS	MS	HS
	L_2	HIS	HS	MS
	L_3	MS	HIS	VHS
	L_4	HIS	HS	VHS
	L_5	MS	VHIS	HIS
Activity Based	A_1	HS	VHIS	MS
	A_2	MS	HS	HIS
	A_3	VHS	HIS	HS
	A_4	HIS	MS	VHIS
Space for Creativity	S_1	HS	VHS	MS
	S_2	MS	HS	HIS
	S_3	VHS	MS	VHIS
Interactive	I_1	MS	HS	HIS
	I_2	HS	VHS	MS
	I_3	VHS	HIS	MS
Time Efficiency	T_1	HS	MS	VHS
	T_2	HIS	HS	VHIS
	T_3	HIS	MS	VHIS

TABLE 5. Aggregated Evaluation Matrix

C	E_1	E_2	E_3	E_1^$_p E_2$^$_p E_3$	Score Value
L_1	(0.9,0.3,0.1)	(0.7,0.2,0)	(0.8,0.2,0.1)	(0.504,0.225,0.19)	**0.217916**
L_2	(0.5,0.2,0.1)	(0.8,0.2,0.1)	(0.7,0.2,0)	(0.28,0.2,0.19)	**0.0423**
L_3	(0.7,0.2,0)	(0.5,0.2,0.1)	(0.9,0.3,0.1)	(0.315,0.25,0.19)	**0.063125**
L_4	(0.5,0.2,0.1)	(0.8,0.2,0.1)	(0.9,0.3,0.1)	(0.36,0.25,0.352)	**0.005696**
L_5	(0.7,0.2,0)	(0.1,0.1,0)	(0.5,0.2,0.1)	(0.35,0.175,0.1)	**-0.00878**
A_1	(0.8,0.2,0.1)	(0.9,0.3,0.1)	(0.7,0.2,0)	(0.504,0.225,0.19)	**0.217916**
A_2	(0.7,0.2,0)	(0.8,0.2,0.1)	(0.5,0.2,0.1)	(0.28,0.2,0.19)	**0.0423**
A_3	(0.9,0.3,0.1)	(0.8,0.2,0.1)	(0.5,0.2,0.1)	(0.36,0.225,0.271)	**0.056159**
A_4	(0.5,0.2,0.1)	(0.7,0.2,0)	(0.7,0.2,0)	(0.245,0.2,0.1)	**0.050025**
S_1	(0.8,0.2,0.1)	(0.5,0.2,0.1)	(0.7,0.2,0)	(0.28,0.2,0.19)	**0.0423**
S_2	(0.1,0.1,0)	(0.8,0.2,0.1)	(0.5,0.2,0.1)	(0.04,0.175,0.19)	**-0.0345**
S_3	(0.7,0.2,0)	(0.9,0.3,0.1)	(0.8,0.2,0.1)	(0.504,0.225,0.19)	**0.217916**
I_1	(0.5,0.2,0.1)	(0.8,0.2,0.1)	(0.7,0.2,0)	(0.28,0.2,0.19)	**0.0423**
I_2	(0.9,0.3,0.1)	(0.5,0.2,0.1)	(0.8,0.2,0.1)	(0.36,0.225,0.271)	**0.056159**
I_3	(0.8,0.2,0.1)	(0.1,0.1,0)	(0.7,0.2,0)	(0.056,0.175,0.1)	**-0.00686**
T_1	(0.8,0.2,0.1)	(0.9,0.3,0.1)	(0.7,0.2,0)	(0.504,0.225,0.19)	**0.217916**
T_2	(0.7,0.2,0)	(0.8,0.2,0.1)	(0.5,0.2,0.1)	(0.28,0.2,0.19)	**0.0423**
T_3	(0.5,0.2,0.1)	(0.8,0.2,0.1)	(0.1,0.1,0)	(0.04,0.15,0.19)	**-0.0345**

The five core criteria's are divided into eighteen sub criteria's with the representation of plithogenic pythagorean set. Based on experts aggregated opinion the first two maximum score values are considered for finding optimal solution.

TABLE 6. Two Maximum Score Values are as follows

Sub-Criteria	Two Maximum Scores
L1	0.21796
L3	0.063125
A1	0.217916
A3	0.056159
S3	0.217916
S1	0.0423
I2	0.056159
I1	0.0423
T1	0.217916
T2	0.0423

The Pythagorean fuzzy decision matrix is

$$Đ(A)=\begin{pmatrix} 0.63 & 0.5225 & 0.649 & 0.8 & 0.88 & 0.56 & 0.72 & 0.7125 & 0.47 & 0.788 \\ 0.383 & 0.7125 & 0.788 & 0.72 & 0.65 & 0.5 & 0.35 & 0.4725 & 0.7 & 0.713 \\ 0.48 & 0.56 & 0.39 & 0.5 & 0.9184 & 0.63 & 0.66 & 0.4275 & 0.67 & 0.92 \\ 0.72 & 0.55 & 0.65 & 0.4725 & 0.7125 & 0.7875 & 0.5225 & 0.65 & 0.45 & 0.653 \\ 0.66 & 0.35 & 0.4275 & 0.6 & 0.56 & 0.72 & 0.6525 & 0.668 & 0.85 & 0.523 \end{pmatrix}$$

TABLE 7. The Nine point scale for Ten criteria's are presented below

Linguistic Variable	Priority	Pythagorean Fuzzy Set	Score Value
Equal relative importance	1	(0.73,0.25)	0.5
Equally to moderately more important	2	(0.73,0.15)	0.5104
Moderately more Important	3	(0.8,0.3)	0.55
Moderately to strongly Important	4	(0.78,0.1)	0.5984
Strongly Important	5	(0.82,0.25)	0.6099
Strongly to very strongly more Important	6	(0.8,0.1)	0.63
Very strongly more Important	7	(0.9,0.3)	0.72
Very strongly to extremely more Important	8	(0.9,0.1)	0.8
Extremely Important (High priority)	9	(0.95,0.175)	0.8719

TABLE 8. Pair wise comparison for Best and Worst criteria is as follows

BO/criteria	c_1	c_2	c_3	c_4	c_5	c_6	c_7	c_8	c_9	c_{10}
Best criteria : c_1(Collaborative)	1	3	1	4	2	7	5	7	2	9

O W/ Worst criteria : c_{10} (Continuous)	
c_1	9
c_2	4
c_3	9
c_4	3
c_5	7
c_6	2
c_7	5
c_8	2
c_9	7
c_{10}	1

By linear programming problem technique we can determine optimum result ψ^*

$\min \psi^*$

$$\text{s.t} \quad \omega_1 - 3\omega_2 \le \psi$$
$$\omega_1 - \omega_3 \le \psi$$
$$\omega_1 - 4\omega_4 \le \psi$$
$$\omega_1 - 2\omega_5 \le \psi$$
$$\omega_1 - 7\omega_6 \le \psi$$
$$\omega_1 - 5\omega_7 \le \psi$$
$$\omega_1 - 7\omega_8 \le \psi$$
$$\omega_1 - 2\omega_9 \le \psi$$
$$\omega_1 - 9\omega_{10} \le \psi$$
$$\omega_2 - 4\omega_{10} \le \psi$$
$$\omega_3 - 9\omega_{10} \le \psi$$
$$\omega_4 - 3\omega_{10} \le \psi$$
$$\omega_5 - 7\omega_{10} \le \psi$$
$$\omega_6 - 2\omega_{10} \le \psi$$
$$\omega_7 - 5\omega_{10} \le \psi$$
$$\omega_8 - 2\omega_{10} \le \psi$$
$$\omega_9 - 7\omega_{10} \le \psi$$

$$\omega_1 + \omega_2 + \omega_3 + \omega_4 + \omega_5 + \omega_6 + \omega_7 + \omega_8 + \omega_9 + \omega_{10} = 1 \quad \& \qquad \omega_j \ge 0, \ \text{for all j}$$

The below normalized weights can be calculated by solving the equations above

$\omega_1 = 0.1134$, $\omega_2 = 0.2059$, $\omega_3 = 0.1134$, $\omega_4 = 0.0764$, $\omega_5 = 0.0875$,

$\omega_6 = 0.0623$, $\omega_7 = 0.0736$, $\omega_8 = 0.0616$, $\omega_9 = 0.087$, $\omega_{10} = 0.1207$,

The optimal solution $\psi^* = 0.000155$

$$\text{Consistency Ratio} = \frac{\psi^*}{\text{consistency index}}$$

$$\text{CR} = \frac{0.000155}{2.3} = 0.00006739 \in (0,1)$$

TABLE 9. The Normalized aggregated values are

criteria / Methods	c_1	c_2	c_3	c_4	c_5	c_6	c_7	c_8	c_9	c_{10}
M1	0.63	0.5225	0.649	0.8	0.88	0.56	0.72	0.7125	0.47	0.788
M2	0.383	0.7125	0.788	0.72	0.65	0.5	0.35	0.4725	0.7	0.713
M3	0.48	0.56	0.39	0.5	0.9184	0.63	0.66	0.4275	0.67	0.92
M4	0.72	0.55	0.65	0.4725	0.7125	0.7875	0.5225	0.65	0.45	0.653
M5	0.66	0.35	0.4275	0.6	0.56	0.72	0.6525	0.668	0.85	0.523

TABLE 10. The Weight and Position of each Criteria is

Criteria	c_1	c_2	c_3	c_4	c_5	c_6	c_7	c_8	c_9	c_{10}
ω^*	0.1134	0.2059	0.1134	0.0746	0.0875	0.0623	0.09718	0.0616	0.087	0.1207
Rank	3	1	4	7	5	9	8	10	6	2
ψ^*	0.000155									

TABLE 11.

Overall score value & Ranking of every various methods

Various methods:	M_1	M_2	M_3	M_4	M_5
Overall Score value(v_i)	0.6571	0.6231	0.6151	0.6118	0.5601
Rank	1	2	3	4	5

5. COMPARATIVE ANALYSIS

In this chapter, we compare BWM with plithogenic pythagorean neutrosophic and neutrosophic set.

Result for neutrosophic set

TABLE 12.

The optimal weight & ranking of every bench mark is

Bench mark	b_1	b_2	b_3	b_4	b_5
ω^*	0.6468	0.0931	0.0994	0.09718	0.0635
Rank	1	4	2	3	5
ψ^*	0.0667				
Comparison	$b_1 > b_3 > b_4 > b_2 > b_5$				

TABLE 13.

Overall score value & Ranking of various methods:

Various methods:	M_1	M_2	M_3	M_4	M_5
Total score	0.5791	0.5861	0.5558	0.5435	0.7553
Ranking	3	2	4	5	1
Comparison	$M_5 > M_2 > M_1 > M_3 > M_4$				

TABLE 14. Result for Plithogenic Pythagorean neutrosophic set

The weight and position of each criteria is

criteria	c_1	c_2	c_3	c_4	c_5	c_6	c_7	c_8	c_9	c_{10}
ω^*	0.1134	0.2059	0.1134	0.0746	0.0875	0.0623	0.09718	0.0616	0.087	0.1207
Rank	3	1	4	7	5	9	8	10	6	2
ψ^*	0.000155									
Comparison	$c_2 > c_{10} > c_1 > c_3 > c_5 > c_9 > c_4 > c_7 > c_6 > c_8$									

TABLE 15.

Overall score value & Ranking of every Various methods:

Various methods:	M_1	M_2	M_3	M_4	M_5
Overall Score value(v_i)	0.6571	0.6231	0.6151	0.6118	0.5601
Rank	1	2	3	4	5
Comparison	$M_1 > M_2 > M_3 > M_4 > M_5$				

From the tables 12 & 14, The plithogenic pythagorean neutrosophic ψ^* shows a better accuracy and very high consistency because ψ^* is very close to zero compare with the neutrosophic set ψ^*.

CONCLUSION

A Multi atribute decision making method (MADM) with B-W method using plithogenic pythagorean neutrosophic fuzzy is discussed in this article. BWM is more effective and less time consuming for obtaining optimal feasible solution comparing to other MCDM approaches. The optimal weights for each criteria are estimated by Linear Programming approach. This technique furnishes an effective aggregated value and best possible score values and also discusses the various decision makers' opinion. In future the real life situations can be solved by several types of multi criteria decision making.

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