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Evaluating and Ranking of Critical Success Factors of Cloud Enterprise Resource Planning Adoption Using MCDM Approach

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ABSTRACT Digital technology advancement and the Internet of Things (IoT) are playing a major role to take a big leap towards achieving Industry 4.0. Cloud-based data management and big data analytics have given rise to adopt Cloud Enterprise Resource Planning (CERP). The CERP has become a significant tool for the success of the information management system (IMS) which is ultimately responsible for the success of any organization. The selection of CERP depends on many critical success factors (CSFs) that must be considered while evaluating and selecting a CERP. In this work, identified CSFs of CERP are modeled using a multi-criteria decision-making (MCDM) approach. The Analytic Hierarchy Process (AHP) and Fuzzy Analytic Hierarchy Process (FAHP) based modelling have been carried out to derive the ranking of the CSFs responsible for the CERP. The group decision-making (GDM) based AHP has also been adopted to build the decision-making model. The paper models 5 Dimensions and 20 sub-criteria factors to provide the prioritized rank of Dimensions and CSFs. The AHP and FAHP models identify the ranking of the 5 Dimensions as Organizational Behavior, Cloud ERP Essentials, Technological Advancement, Innovational Ideas, and Environmental Impact.

INDEX TERMS Analytic hierarchy process (AHP), cloud enterprise resource planning (CERP), fuzzy AHP (FAHP), industry 4.0, information system (IS), information technology (IT).

I. INTRODUCTION

An enterprise resource planning (ERP) system is an application software with various modules which satisfy the needs of an organization and customers by assisting the complex problems of sharing crucial information, managing different resources, and integrating different operations of the organization's business among various departments [1]. It exchanges the information and provides backbone support to a business organization. It has become demanding for almost every organization to combat market pressure from peer organizations. It has become essential for an organization to grow to ensure market share and satisfy customers' demands. Business organizations moving towards Industry 4.0 commitment would prefer to adopt the ERP to obtain a competitive advantage globally. ERP provides a powerful information system (IS) to the organization that can manage complex customer services. It can increase operational efficiency thus more popular among business entrepreneurs. Cloud enterprise resource planning (CERP) provides access over the internet thus ensures easy access from anywhere at any time. ERP and CERP are the two variants commonly used by organizations. ERP is a factory-based system while CERP provides service irrespective of the factory premises. The selection of appropriate ERP systems that attain the business strategic need and accomplish an organizational goal is a challenge to entrepreneurs.

An organization must manage its information technology (IT) infrastructure to take advantage of ERP solutions. They are also keen on CERP solutions because ERP on the

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premise requires substantial investment in software and hardware and its maintenance expenses. CERP permits cloud-based operations hence its services can be accessed using the cloud. It provides a cutting edge over conventional enterprise systems. Cloud computing provides improved IT services with ease [2]. This practice has distinct economic benefits, especially as it is cost-effective where the pay-as-you-go model is used by cloud service providers [3]. It is one of the primary pillars among the four pillars of Industry 4.0 [4]. CERP is an automated, scalable, and customizable IS that manages enterprise operations to retain unified organization-wide records. It ensures a more agile business solutions package that responds to evolving business needs. CERP helps in sustainable performance and enables organizations to include cloud storage of online personal data, cloud virtual machines, cloud computing platforms, and other organization-based services. Any user can use these services from any part of the world with a click of the mouse [4]. CERP is the same for on-site ERP but is substantially cheaper due to off-site implementation, support, and maintenance [5]. While theoretically, the main distinction between CERP and ERP is the programmer's geographic position which has some essential variations. It is available at affordable costs without large upfront hardware and development expenses, as device services could subscribe every month. Any organization can quickly scale the business efficiency tools with the right cloud services when its market is rising or when a new enterprise is being incorporated. CERP system is constructive for organizational performance as an alternative to the conventional ERP framework, which increases the efficiency of the decision-making method. A recent study has presented the hidden linkage between CERP and attributes of sustainable organizations [6].

Different researchers studied the attitude and intention of users in adopting CERP software such as the Diffusion of Innovation (DOI) [7]–[9], Theory of planned behavior [1], Technology Acceptance Model [1], [8], [10], [11], Technology Organization Environment (TOE) [7], [9], [12], [13], Task Technology Fit [8], and Theory of Reasoned Action [13]. Critical success factors (CSFs) are the important measurable and controllable factors, essential variables, and areas that can improve the performance of the organization, if they are taking care of properly they can flourish the business of the organization [14], [15]. Various success factors, which affect the success and failures of the CERP system. Evaluating these factors can help organizations to monitor and control a successful CERP system. This study aims at the following objectives:

- To prepare a literature-based framework and identify CSFs of the CERP system.
- To evaluate and rank CSFs of the CERP system for subsequent modeling using AHP in crisp and fuzzy environments.

The research work has been organized as follows: Section II shows the framework for the identification of CSFs in CERP, stepwise AHP and FAHP methodology is documented in Section III, whereas Section IV provides case illustration and application using AHP and FAHP methodology in the CERP. Detailed results and discussion on evaluation and ranking of CSFs of CERP are given in Section V. Section VI discusses the limitations of the present work and conclusions are given at the end in Section VII.

II. RELATED WORKS

In the information technology-based revolution, the CERP system plays a significant role hence many researchers carry out their stud on it. A detailed review of literature for CERP and MCDM based research methodology has been carried out and provided under different sub-sections, namely multi-criteria-based research method and framework for the identification of CSFs in CERP.

A. MULTI-CRITERIA BASED RESEARCH METHOD

From the review of literature on CSFs of CERP and MCDM based modeling, it is revealed that many researchers have carried out studies in these areas. MCDM are used for ranking, sorting, and finding the best possible factors in different studies. AHP is one of the widely used MCDM methods for ranking and finding priority among different factors [16]. Meghna (2018) found some influential and important CERP adoption factors for multinational companies (MNCs) of India and subsequently used AHP to model and rank. The result of this research helps the vendors of CERP to find the most influential factors and make a strategy accordingly [17]. Lopez and Ishizaka (2017) proposed GAHP Sort method with the help of AHP for sorting and finding the most suitable CERP package among different vendors which are present in the market. They have also used the Analytic Network Process (ANP) on different selected vendors to select the final vendor for CERP [16].

In the exploratory research of Bharathi and Mandal (2015), 17 significant success factors were identified were modeled using AHP for sustainable CERP for small and medium-sized enterprises (SMEs. Selected SME partners and consultants participated in this exploratory research study. Their study found that the most important factors are related to cost. Their study can help the stakeholders in selecting a proper sustainable CERP system [18]. Naveed *et al.* (2019) investigated the CSFs of Cloud-based E-Learning and employed AHP in the crisp and fuzzy environment for subsequent evaluating and ranking [15]. Bhatt *et al.* (2021) Investigated and ranked several factors touching ERP adoption decisions for SMEs, explicitly in the context of the Indian market with the help of the Fuzzy AHP method [19]. Fuzzy has also been used to create a framework for usability evaluation of different academic websites by classifying and prioritizing them [20].

B. IDENTIFICATION OF CSFs OF CERP USING LITERATURE BASED FRAMEWORK

The Dimensions and CFSs of CERP are very significant in identifying and adopting the CERP system for any

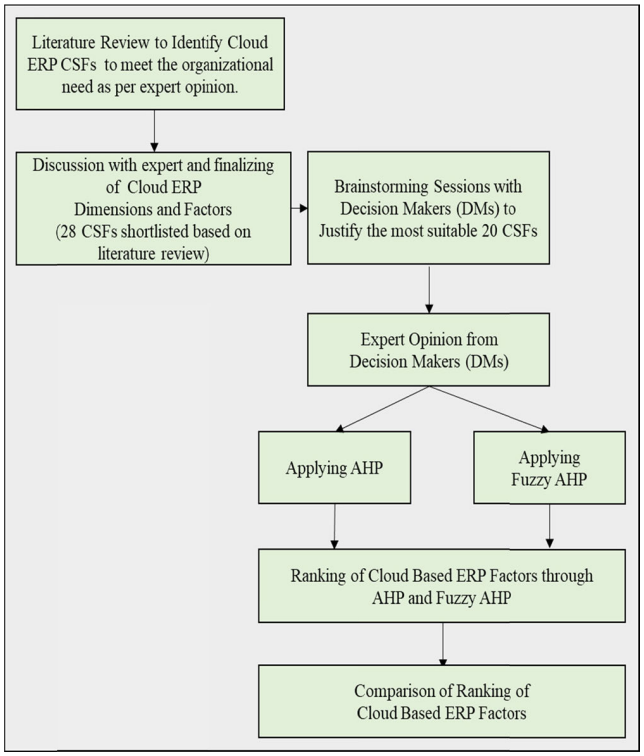

FIGURE 1. Multi-phases literature-based framework for CERP.

TABLE 1. Factors related to CERP essentials.

Dimensions	CSFs	References
Cloud ERP Essentials (CE)	Cloud Security (CS)	[21], [22], [23], [24], [25], [7], [26]
	Data Privacy (DP)	[21], [5], [27], [28], [29], [29]
	Relative Advantages (RA)	[7], [22], [8], [24], [30], [9], [7]
	Perceived Risk (PR)	[11], [31], [32], [33], [6]

TABLE 2. Factors related to technological advancement.

Technological Advancement (TA)	Network Latency and Infrastructure (NLI)	[35], [5], [22], [12], [26], [24], [36], [37], [29], [29], [26], [34], [38], [39]
	Data Integrity (DI)	[39], [5], [38], [34]
	System Support and Testing (SST)	[23], [26], [34], [38], [23], [27], [8], [33], [39], [40]
	Scalability (SC)	[33], [6], [41], [30], [42]

organization. Hence, a multi-phases literature-based framework is prepared. In the initial phase, various CSFs of CERP were studied. After a detailed study, their applicability for the present research was carried out. At the end of this study 28, CSFs were shortlisted in consultation with Decision Makers (DMs).

In the second phase, a brainstorming session was organized for DMs. During the brainstorming, all the participants were briefed about the AHP methodology and identified CSFs. At the end of the session, 20 CSFs were identified and subsequently grouped into four Dimensions. The CSFs identification thorough multi-phases literature-based framework is shown in Figure 1.

1) CERP ESSENTIALS

In CERP selection and its subsequent adoption, CERP Essentials plays a vital role. It includes various factors like trust which plays a significant role in managing data privacy, security with minimum cost [21]. The organization that wants to adopt a CERP system should have a cutting edge over the other applications available in the market [22]. The perceived risk of sharing information through the CERP system is also one of the factors that are crucial for the adoption of CERP [6]. Many researchers considered these important Dimensions as a vital need for the implementation of CERP. It includes factors like security, privacy, relative advantages over other applications and perceived risk. Table 1 provides Dimensions and CSFs of CERP.

2) TECHNOLOGICAL ADVANCEMENT

Many researchers considered Technological Advancement as one of the important Dimensions and is a vital need for the successful implementation of CERP. Technological essentials require network latency and infrastructure for proper implementation of the CERP system [22]. It is also important for organizations to adopt system support services and testing of a web-based application for proper functioning and maintenance of the CERP system [34]. The scalability of the CERP system is also one of the factors that are crucial for the adoption of the CERP system as it is required to be updated with the technology [6]. Data integrity is one of the major factors required for the proper functioning of the CERP system [34]. The CSFs related to the Technological Advancement Dimension are presented in Table 2.

3) INNOVATIONAL IDEAS

Innovational Ideas for any CERP need functionality and reliability of the software support from the main server [39]. The successful working of CERP is based on its web-based compatibility, proper functioning with effective maintenance [24]. The complexity of CERP usage is also one of the factors that are crucial for the adoption of the CERP system as it is required to be updated with the technology [8], [27]. The study of Gupta *et al.* (2018) [34] concluded that business functionality poses a challenge to SMEs. It was also revealed that limited functionality is the topmost concern for any SMEs or large organizations. Table 3 presents the Dimension and CSFs related to the Innovational Ideas.

TABLE 3. Factors related to innovational ideas.

Innovational Ideas (IA)	Functionality (FU)	[34], [5], [38], [39]
	Functionality (CO)	[7], [22], [8], [24], [30], [28], [23],
	Complexity of Usage (CU)	[7], [5], [22], [27], [8], [24], [9], [23], [25]
	Reliability (RE)	[43], [8], [24], [21], [23]

TABLE 4. Factors related to environmental impact.

Environmental Impact (EI)	Competitive Pressure (CP)	[12], [21], [7], [22], [36], [24]
	Regulatory Support (RS)	[24], [12], [22], [12], [36], [7], [13], [44], [6]
	External Vendor Support (EVS)	[27], [23], [40], [34], [38], [41], [24], [37], [33], [44], [40], [7], [36], [28], [44], [6]

4) ENVIRONMENTAL IMPACT

Environmental Impact Dimension requires Regulatory support from the organizations [6]. It is also important for organizations to adopt External Vendor Support for the proper functioning and maintenance of the CERP system [40]. Competitive pressure is also one of the factors that are crucial for the adoption of the CERP system as it keeps the organization updated with the technology [24]. Table 4 presents the Dimension and CSFs related to the Environmental.

5) ORGANIZATIONAL BEHAVIOR

Organizational Essentials Dimension requires Top management approval and support [21], [30], [36]–[21]. It is also important for organizations to adopt strategic implementation with the appropriate finances and budget management [5], [39]. The organizational culture and size also have an impact on the successful adoption of the CERP system [7]. References [28] and [30] listed the most potent acceptance CERP factors such as Top Management Support, Compatibility, Budget for technology readiness in SMEs. Table 5 presents the Dimension and CSFs related to Organizational Behaviour.

C. RESEARCH METHODOLOGIES

MCDM based methodologies are widely employed for solving many engineering and non-engineering-based problems. AHP is a MCDM methodology that may involve the single DM or a group of decision-makers (GDM) generally referred to as AHP-GDM. A multi-step AHP-GDM and FAHP are described in this section. AHP is simple and capable of solving MCDM based problems. AHP uses Saaty's scale of 1-9 points with an intermediate selection of 2,4,6,8 points for pairwise comparison. FAHP uses extension principles, fuzzy set theory and fuzzy numbers hence providing more range in a pairwise comparison. Thus FAHP helps in providing more accuracy in the decision-making.

TABLE 5. Factors related to organizational behaviour.

Organizational Behaviour (OB)	Top Management Support (TMS)	[21], [7], [23], [12], [22], [26], [24], [30], [36]
	Organizational Size (OS)	[7], [24], [12]
	Organizational Culture (OC)	[22], [36], [9], [23], [33], [41], [23], [6]
	Strategic Management (SM)	[5], [23], [40], [7], [34], [38], [45], [33], [33], [34]
	Project Budget and Financial Support (PBF)	[13], [28], [37], [42], [21], [7], [41], [30], [28], [33], [44], [44], [25], [42], [6], [5], [39], [38]

TABLE 6. Scale to compare dimensions and CSFS to establish relationships.

Digits	The relative importance of the two criteria
2,4,6,8	Compromise between slightly different judgements
9	Absolutely more important
7	Demonstrably more important
5	Strongly more important
3	Slightly more important
1	Equally important

1) AHP METHODOLOGY

$$A = \begin{bmatrix} C_{11} & \cdots & C_{1n} \\ \vdots & \ddots & \vdots \\ C_{1m} & \cdots & C_{mn} \end{bmatrix} \tag{1}$$

$$C_{ii} = 1, \quad C_{ij} = {}^{1}/_{C_{ji}}, \; C_{ji} \neq 0 \tag{2}$$

where the Dimension or CSF may be represented by C_1, C_2, $\ldots C_{\mathrm{mn}}$. The Saaty's scale [2] as shown in Table 6 may be used to provide relative importance between two Dimensions or CSFs.

The consistency ratio (CR) and consistency index (CI) is calculated from equations 3 to 4 to ensure consistency where n denotes the number of criteria. The pairwise comparison matrix is acceptable if the CR is < 0.1. Table 7 shows a random index for a given n.

$$CR = \frac{CI}{RI} \tag{3}$$

$$CI = (\lambda_{max} - n) \,/\, (n-1) \tag{4}$$

2) FAHP METHODOLOGY

The fuzzy set theory uses fuzzy numbers in pairwise comparison hence Saaty's 9-point scale is replaced with commonly used triangular fuzzy numbers (TFNs) or Trapezoidal

TABLE 7. Random index.

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

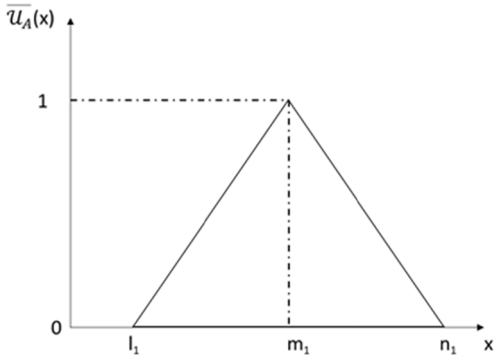

FIGURE 2. Triangular fuzzy number $\tilde{Q}$.

Fuzzy Number (TrFN). To find the intersection of two fuzzy sets, the extension principle can be used. The TFN provides more flexibility to DM while pairwise comparison hence the decision-making can be accurate. AHP may employ a single DM or group of DMs. A single DM may be biased or finds limited choice in his decision-making hence it becomes challenging for a DM. The decision-making may rely on the individual competency of the decision-maker (DM). FAHP removes the problem of limited choice in comparison by providing more flexibility using fuzzy numbers. Thus the decision-making becomes more robust, easy, accurate and free from vagueness [47]. The extension principle provides a fuzzy pairwise comparison of fuzzy numbers in decision-making. The following section introduces the fuzzy set theory and extension principles:

a: FUZZY SET THEORY

The fuzzy set theory provides the use of fuzzy arithmetic operations that involves fuzzy numbers. The DMs may use various types of fuzzy numbers i.e. TFN, TrFN as per their capability and provides a pairwise comparison. The TFN (l_1, m_1, n_1) can be used in pair-wise decision-making [48]. A TFN is shown in Figure 2.

The various arithmetic operations may be performed using fuzzy numbers [49], considering fuzzy numbers $\tilde{Q}_1 = (l_1, m_1, n_1)$ and $\tilde{Q}_2 = (l_2, m_2, n_2)$.

A various arithmetic operation like subtraction, addition, division, and multiplication can be performed using various equations (6-10):

$$\tilde{Q}_1 \oplus \tilde{Q}_2 = (l_1 + l_2, m_1 + m_2, n_1 + n_2) \quad (5)$$

$$\tilde{Q}_1 \ominus \tilde{Q}_2 = (l_1 - l_2, m_1 - m_2, n_1 - n_2) \quad (6)$$

$$\tilde{Q}_1 \otimes \tilde{Q}_2 = (l_1 l_2, m_1 m_2, n_1 n_2) \quad (7)$$

$$\lambda \otimes \tilde{Q}_1 = (\lambda_1 b_1, \lambda_1 c_1, \lambda_1 d_1) \quad \text{where } \lambda > 0,\ \lambda \epsilon R \quad (8)$$

$$\tilde{Q}_1^{-1} = \left(\frac{1}{n_1}, \frac{1}{m_1}, \frac{1}{l_1}\right) \quad (9)$$

b: APPLICATION OF THE THEORY OF EXTENT ANALYSIS IN MCDM IN FUZZY ENVIRONMENTS

Two triangular fuzzy numbers (TFNs) can be compared using the Extent principle [50]. A set of priorities and a set of targets may be viewed as two sets, i.e. $Y = \{y_1, y_2, \ldots\ldots, y_n\}$ and $Z = \{z_1, z_2, \ldots\ldots, z_3\}$ respectively. Therefore, each objective can be identified employing the extension principle. Extent analysis is performed to achieve the set goal. Considering f extent analysis, the following objective may be obtained:

$$Q_{gi}^1, Q_{gi}^2 \ldots Q_{gi}^f, \quad i = 1, 2, \ldots, n \quad (10)$$

where Q_{gi}^j $(j = 1, 2, \ldots f)$ are various TFNs and represented by fuzzy numbers (k, m, n). The extent analysis transformation further explained.

Step 1:*To establish relationship structure for CERP adoption using Dimension and CSFs*

The CERP relationship structure possesses the main objective of evaluation and prioritization of Dimensions and CSFs. Thus using the Dimensions and CSFs under various Dimension group a relationship structure can be established into a various stepwise hierarchy..

Step 2:*To obtain pair-wise comparison for Dimension and CSFs of CERP*

The CERP structure has Dimensions and CSFs into a different hierarchies. Each Dimension may be compared with another dimension or CSF may be compared with another CSF.

The final pair-wise comparison of each Dimension and CSFs of CERP can be obtained with the help of DMs.

Step 3: To perform *fuzzy synthetic extent analysis*

$$F_i = \sum_{j=1}^{m} Q_{gi}^j \otimes \left[\sum_{i=1}^{n} \sum_{j=1}^{m} Q_{gi}^j\right]^{-1} \text{i} = 1 \quad (11)$$

Using fuzzy summation of TFNs, f extent analysis values $\sum_{j=1}^{f} Q_{gi}^j$, may be obtained as:

$$\sum_{j=1}^{f} Q_{gi}^j = \left(\sum_{j=1}^{f} l_j, \sum_{j=1}^{f} m_j, \sum_{j=1}^{f} n_j\right) \text{j} = 1 \quad (12)$$

and $\left[\sum_{j=1}^{n} \sum_{j=1}^{f} Q_{gi}^j\right]^{-1}$, gives the fuzzy summation of Q_{gi}^j $(j = 1, 2, \ldots, m)$ values are calculated as

$$\sum_{i=1}^{n} \sum_{j=1}^{f} N_{gi}^j = \left(\sum_{j=1}^{f} l_j, \sum_{j=1}^{f} m_j, \sum_{j=1}^{f} n_j\right) \text{i} = 1 \quad (13)$$

The inverse of the vector may be obtained as:

$$\left[\sum_{i=1}^{n} \sum_{j=1}^{f} Q_{gi}^j\right]^{-1} = \left(\frac{1}{\sum_{i=1}^{n} n_i}, \frac{1}{\sum_{i=1}^{n} m_i}, \frac{1}{\sum_{i=1}^{n} l_i}\right) \text{i} = 11 \quad (14)$$

TABLE 8. Pairwise comparison of CERP Dimensions using AHP by DM1.

	CE	TA	II	EI	OB	Weightages
CERP Essentials (CE)	1	3	5	7	$\frac{1}{2}$	0.3084
Technological Advancement (TA)	$\frac{1}{3}$	1	5	7	$\frac{1}{3}$	0.1870
Innovational Ideas (II)	$\frac{1}{5}$	$\frac{1}{5}$	1	3	$\frac{1}{5}$	0.0657
Environmental Impact (EI)	$\frac{1}{7}$	$\frac{1}{7}$	$\frac{1}{3}$	1	$\frac{1}{7}$	0.0348
Organizational Behavior (OB)	2	3	5	7	1	0.4042

λ_{max} = 5.3275, CR = 0.0728, CI = 0.0819, RI=1.12

TABLE 9. Pairwise comparison of CERP Dimensions using AHP by DM2.

	CE	TA	IA	EI	OB	Weightages
Cloud ERP Essentials (CE)	1	5	7	5	$\frac{1}{2}$	0.3521
Technological Advancement (TA)	$\frac{1}{5}$	1	2	5	$\frac{1}{5}$	0.1166
Innovational Ideas (II)	$\frac{1}{7}$	$\frac{1}{2}$	1	3	$\frac{1}{3}$	0.0823
Environmental Impact (EI)	$\frac{1}{5}$	$\frac{1}{5}$	$\frac{1}{3}$	1	$\frac{1}{7}$	0.0404
Organizational Behavior (OB)	2	5	3	7	1	0.4086

λ_{max} = 5.4465, CR = 0.0993, CI=0.1116, RI=1.12

TABLE 10. Pairwise comparison of CERP dimensions using AHP by DM3.

	CE	TA	IA	EI	OB	Weightages
Cloud ERP Essentials (CE)	1	3	5	3	$\frac{1}{3}$	0.2741
Technological Advancement (TA)	$\frac{1}{3}$	1	2	3	$\frac{1}{4}$	0.1302
Innovational Ideas (II)	$\frac{1}{5}$	$\frac{1}{2}$	1	3	$\frac{1}{3}$	0.0997
Environmental Impact (EI)	$\frac{1}{3}$	$\frac{1}{3}$	$\frac{1}{3}$	1	$\frac{1}{5}$	0.0580
Organizational Behavior (OB)	3	4	3	5	1	0.4381

λ_{max} = 5.4104, CR = 0.0912, CI=0.1026, RI=1.12

Step 4: To obtain *the degree of possibility of supremacy for two TFNs i.e.*$Q_2 = (k_2, m_2, n_2) \geq Q_1 = (k_1, m_1, n_1)$

$$V(Q_2 \geq Q_1) = sup\left[min(\mu_{Q_1}(x), \mu_{Q_2}(y))\right], \quad y \geq x \tag{15}$$

and can be represented as:

$$V(Q_2 \geq Q_1) = hgt(Q_1 \cap Q_2) = \mu_{Q_2}(f) \tag{16}$$

$$\mu_{Q_2}(f) = \begin{cases} 0 & if\ m_2 \geq m_1 \\ 1 & if\ l_1 \geq n_2 \\ \dfrac{l_1 - n_2}{(m_2 - l_2) - (m_1 - l_1)} & otherwise \end{cases} \tag{17}$$

A DM or a group of DMs may be consulted in deriving the pair-wise comparison for the given decision matrix A in FAHP. Thus the participating DM for instance h may be considered. The subsequent pair-wise comparisons yield n elements. A set of H matrices, $\breve{A}_h = \{\breve{q}_{ijk}\}$, where $\breve{A}_a = \breve{q}_{ija} = (l_{ijk}, m_{ijk}, u_{ijk})$ represents the relative importance of element i to j, as derived by DM k. The aggregation may be obtained using Equation (18).

$$\begin{aligned} l_{ij} &= min\left(l_{ijk}\right), \quad k = 1, 2, \ldots k \\ m_{ij} &= \sqrt[k]{\prod_{k=1}^{K} m_{ijk}} \\ n_{ij} &= max\left(u_{ijk}\right), \quad h = 1, 2, \ldots k \end{aligned} \tag{18}$$

The two TFNs i.e. (l_1, m_1, n_1) and (l_2, m_2, n_2) intersect at d which is shown in Figure 3. It also gives ordinate d, from the possible highest intersection between two fuzzy numbers Q_1 and Q_2 denoted as Q. Thus Q_1 and Q_2, maybe calculated through the values of $V(Q_1 \geq Q_2)$ and $V(Q_2 \geq Q_1)$.

Step 5:*To obtain the degree of possibility of a convex fuzzy number greater than b convex*

Further, Q_1 $(i = 1, 2, \ldots., b)$ may be transformed as

$$\begin{aligned} &V(Q \geq Q_1, Q_2 \ldots . Q_b) \\ &\quad = V[(Q \geq Q_1)\ and\ (Q \geq Q_2\ and \\ &\qquad \ldots\ldots\ldots and\ (Q \geq Q_b))] \\ &\quad = \min V(Q \geq Q_i), \quad i = 1, 2, \ldots\ldots\ldots, b \end{aligned} \tag{19}$$

Considering,

$$d'(B_i) = \min V(S_i \geq S_k) for b = 1, 2, \ldots.., m; b \neq i \tag{20}$$

The weight vector is may be derived as $G' = \left(d'(B_1), d'(B_2), \ldots\ldots\ldots, d'(B_n)\right)^T$, such that $B_i(i = 1, 2, \ldots.., n)$ has n elements

Step 6: *Obtain the normalized weight vectors.*

The equation (21) may be employed to calculate normalized weight vector as:

$$E = (d(B_1), d(B_2), \ldots\ldots\ldots, d(B_n))^T \tag{21}$$

where the crisp number may be represented by E.

Step 7: *To obtain the final rank of each Dimension or CSFs*

The product of Dimension and CSFs of CERP will provide global weight that may be considered for the final ranking of each Dimension and CSFs of CERP. The obtained priority may be arranged into a descending order to get the ranking.

III. APPLICATION OF MCDM BASED METHODOLOGIES IN THE CERP

The MCDM based AHP and FAHP may be thus employed to evaluate and prioritize the Dimensions and CSFs of CERP. Various feedback from the DMs group may be further synthesized. Five expert DMs from various organizations were selected to provide feedback in the prioritization of CSFs of CERP. A multiphase framework based on a literature review was followed. The relationship matrix consists of four Dimensions and twenty-four CSFs identified using the

TABLE 11. Pairwise comparison of CERP Dimensions using AHP by DM4.

	CE	TA	IA	EI	OB	Weightages
Cloud ERP Essentials (CE)	1	1	5	3	2	0.3237
Technological Advancement (TA)	1	1	5	3	$\frac{1}{2}$	0.2434
Innovational Ideas (II)	$\frac{1}{5}$	$\frac{1}{5}$	1	2	$\frac{1}{5}$	0.0734
Environmental Impact (EI)	$\frac{1}{3}$	$\frac{1}{3}$	$\frac{1}{2}$	1	$\frac{1}{3}$	0.0740
Organizational Behavior (OB)	$\frac{1}{2}$	2	5	3	1	0.2855

λ_{max} = 5.3366, CR = 0.0748, CI=0.0841, RI=1.12

TABLE 12. Pairwise comparison of CERP dimensions using AHP by DM5.

	CE	TA	IA	EI	OB	Weightages
Cloud ERP Essentials (CE)	1	$\frac{1}{3}$	2	5	$\frac{1}{3}$	0.1645
Technological Advancement (TA)	3	1	3	3	$\frac{1}{3}$	0.2546
Innovational Ideas (II)	$\frac{1}{2}$	$\frac{1}{3}$	1	2	$\frac{1}{3}$	0.0980
Environmental Impact (EI)	$\frac{1}{5}$	$\frac{1}{3}$	$\frac{1}{2}$	1	$\frac{1}{5}$	0.0581
Organizational Behavior (OB)	3	3	3	5	1	0.4249

λ_{max}= 5.3344, CR = 0.0743, CI= 0.0836, RI=1.12

TABLE 13. Synthesizing results by DM1 to DM5 for CERP dimensions using AHP.

	CE	TA	IA	EI	OB	Weightages
Cloud ERP Essentials (CE)	1	$\frac{15}{7}$	$\frac{44}{9}$	$\frac{41}{3}$	$\frac{5}{9}$	0.2826
Technological Advancement (TA)	$\frac{4}{7}$	1	$\frac{31}{8}$	4	$\frac{1}{3}$	0.1821
Innovational Ideas (II)	$\frac{2}{9}$	1/3	1	$\frac{25}{9}$	$\frac{1}{4}$	0.0849
Environmental Impact (EI)	$\frac{2}{9}$	$\frac{1}{4}$	$\frac{2}{5}$	1	$\frac{1}{5}$	0.0525
Organizational Behavior (OB)	$\frac{17}{9}$	$\frac{31}{4}$	$\frac{32}{3}$	$\frac{51}{6}$	1	0.3980

λ_{max}= 5.1741, CR = 0.0389, CI= 0.0435, RI=1.12

feedback of the brainstorming session. Figure 4 indicates the relationship structure derived using the multiphase framework of CERP. Various Dimensions of CERP are evaluated by DMs and shown in Table 6 -10. The synthesized value may be obtained by combining the five decision matrices using the geometric mean method (GMM). The synthesized pairwise comparison matrix is shown in Table 11 synthesizing all the values. Similarly, a pairwise comparison of different CERP factors is also calculated. The composite weight of all CERP factors obtained through the AHP is shown in Table 12.

FAHP has also been applied for the CERP Dimension and Factor's weight calculation and to get its ranking. TFN scale values as shown in Table 13 have been used in attaining the weights for the CERP Dimensions and its Factors.

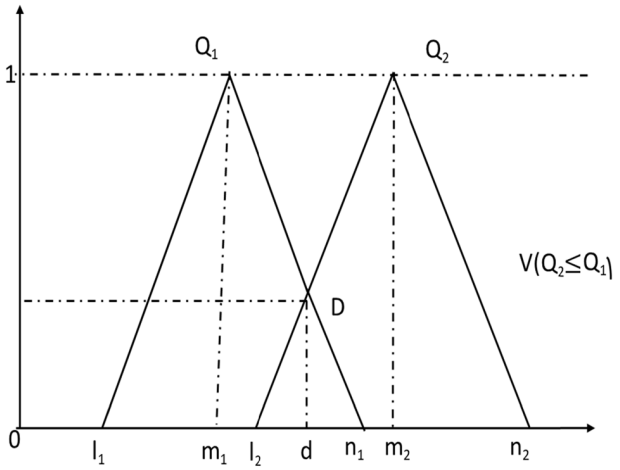

FIGURE 3. The intersection of TFNs [41].

The systematic research methodology as illustrated in the previous section has been pursued to determine the weights. Table 14 shows the weights after the pairwise comparison of the CERP Dimensions of using FAHP. Table 15 shows the composite weights and ranks of CERP Factors obtained through the FAHP using TFN. The prioritization obtained using AHP and FAHP may be compared and shown in Table 16. Moreover, Figure 5-6 shows the weights of Dimensions and their respective factors. While Figure 7 shows the overall ranking of factors using AHP and FAHP.

IV. RESULTS AND DISCUSSIONS

The MCDM is useful in critically analyzing factors, CSFs and Dimensions etc. to help in decision-making in selecting a potential ERP or CERP system. Since CSFs play a vital role for the selection of CERP for any organization so that administrative managers can buy an appropriate ERP/CERP system for the organization. The selected ERP/CERP system must be in a position to cater to the needs of the organization. Looking to the requirements AHP and Fuzzy AHP based modeling has been used in the present condition. The AHP and FAHP have great potential to evaluate and rank the Dimensions and CSFs that are significant decision-making parameters while selecting CERP for any organization. Based on the selected Dimensions and CSFs the stakeholders will be able to carry out smooth and efficient execution of the CERP system. It would be easy for business entrepreneurs to constantly review, track, and handle their CERP system to align with their strategic objectives. Since expensive infrastructure (hardware and software) technologies are needed to support the effective and robust execution of CERP, the CSFs can assist in efficient resource planning and management. The accurate prioritization can be obtained using AHP and FAHP ranking and their subsequent comparison.

The AHP provides the ranking of Dimension of the CERP as: Organizational Behaviour, 0.3980 > Cloud ERP Essentials, 0.2826 > Technological Advancement, 0.1821 >

TABLE 14. Composite rank and weight of CERP dimensions and factors using AHP.

Dimensions	Dimension weights	Factors	Local Weights	Global Weights	AHP Ranking
Cloud ERP Essentials (CE)	0.2826	Cloud Security	0.4871	0.1377	2
		Data Privacy	0.1051	0.0297	9
		Relative Advantages	0.3468	0.0980	5
		Perceived Risk	0.0610	0.0172	16
Technological Advancement (TA)	0.1821	Network Latency and Infrastructure	0.5820	0.1060	4
		Data Integrity	0.1119	0.0204	13
		System Support and Testing	0.2509	0.0457	8
		Scalability	0.0551	0.0100	17
Innovational Ideas (II)	0.0849	Functionality	0.5852	0.0497	7
		Compatibility	0.2504	0.0213	12
		Complexity of Usage	0.0500	0.0042	20
		Reliability	0.1144	0.0097	18
Environmental Impact (EI)	0.0525	Competitive Pressure	0.0837	0.0044	19
		Regulatory Support	0.3567	0.0187	14
		External Vendor Support	0.5596	0.0294	10
Organizational Behavior (OB)	0.3980	Top Management Support	0.4878	0.1941	1
		Organizational Size	0.0450	0.0179	15
		Organizational Culture	0.0601	0.0239	11
		Implementation Strategic Management	0.2816	0.1121	3
		Project Budget and Financial Benefit	0.1255	0.0499	6

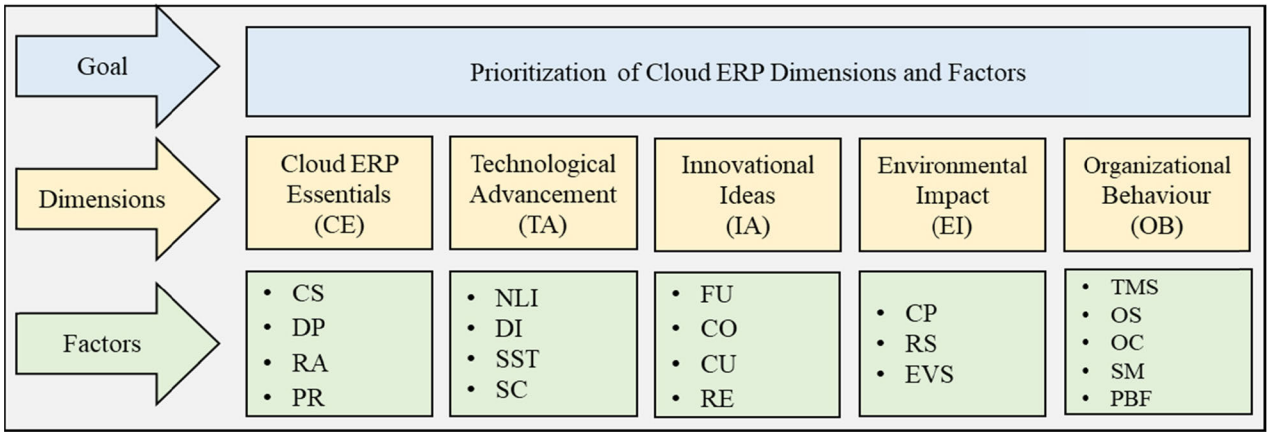

FIGURE 4. Framework for ranking CERP dimensions and factors.

Innovational Ideas, 0.0849 > Environmental Impact, 0.0525, where '>' indicate the preference over other. From the result, it may be concluded that the Organizational Behaviour Dimension plays a significant role whereas Environmental Impact plays comparatively a less significant role in CERP success. Top management support is essential in the CERP selection and implementation. The organizational size and culture also influence the CERP selection. The availability of the project budget and financial support is the backbone for the CERP selection. The influence of Top five CSFs of the CERP found through AHP are Top Management Support, 0.1941 > Cloud Security, 0.1377 > Implementation Strategic Management, 0.1121 > Network Latency and Infrastructure, 0.1060 > Relative Advantages, 0.0980, where '>' indicate the preference over other.

Similarly, the FAHP provides the results as: Organizational Behaviour, 0.3957 > Cloud ERP Essentials, 0.2767 > Technological Advancement, 0.1846 > Innovational Ideas, 0.0905 > Environmental Impact, 0.0526, where '>' indicate the preference over other. It is concluded that the Organizational Behaviour Dimension plays a significant role whereas Environmental Impact plays comparatively a less significant

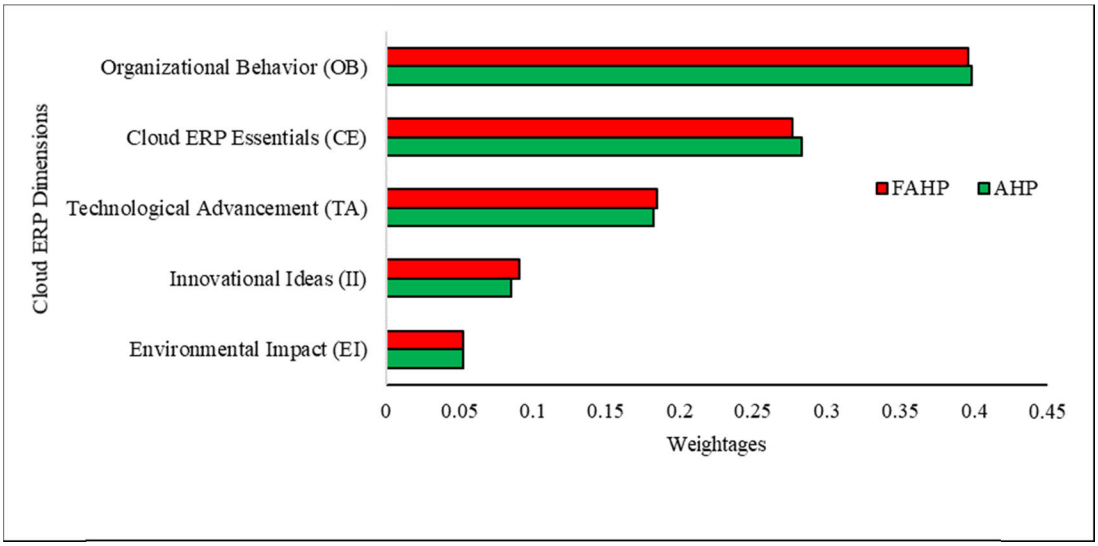

FIGURE 5. Weightages of dimensions.

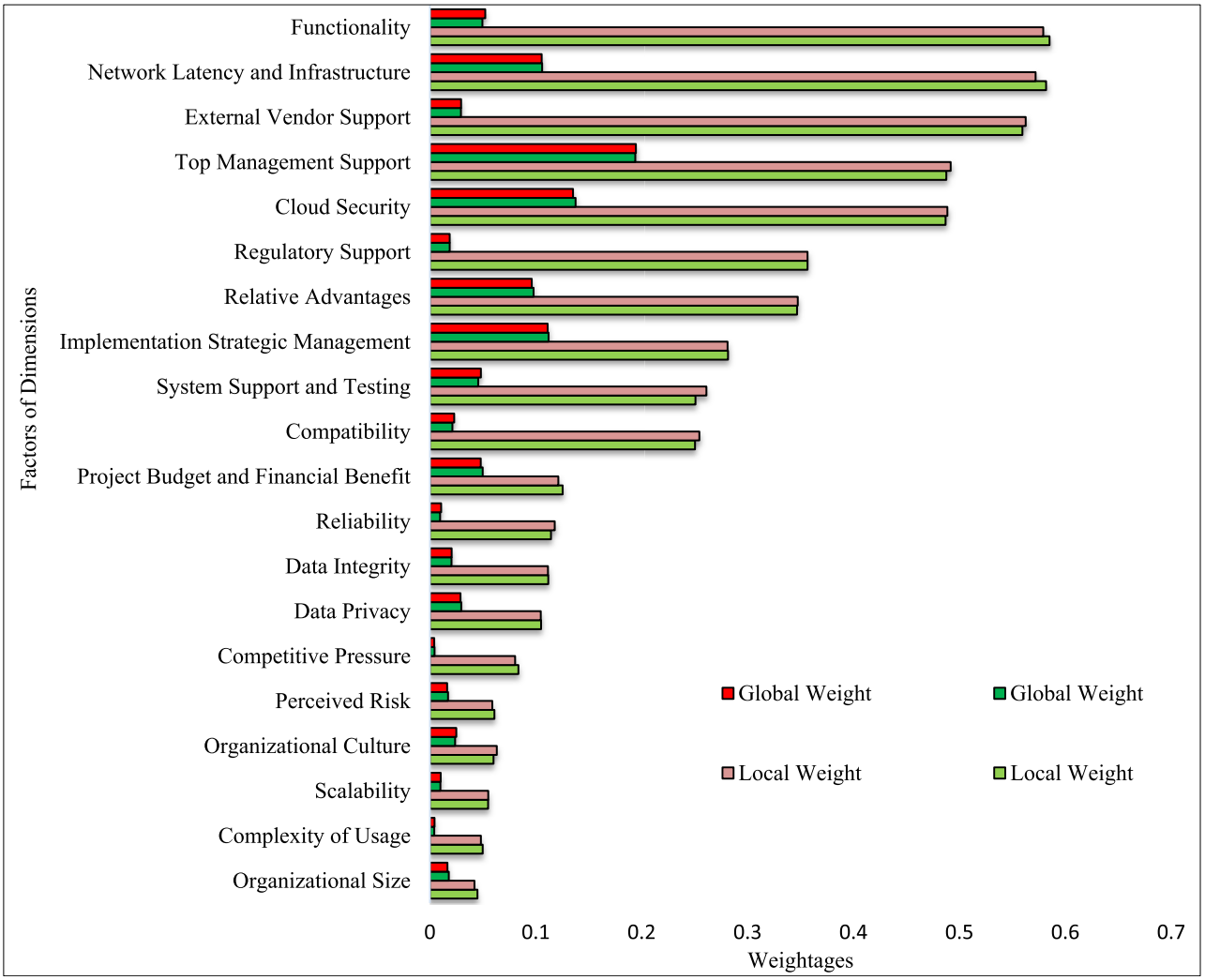

FIGURE 6. Weightages of factors.

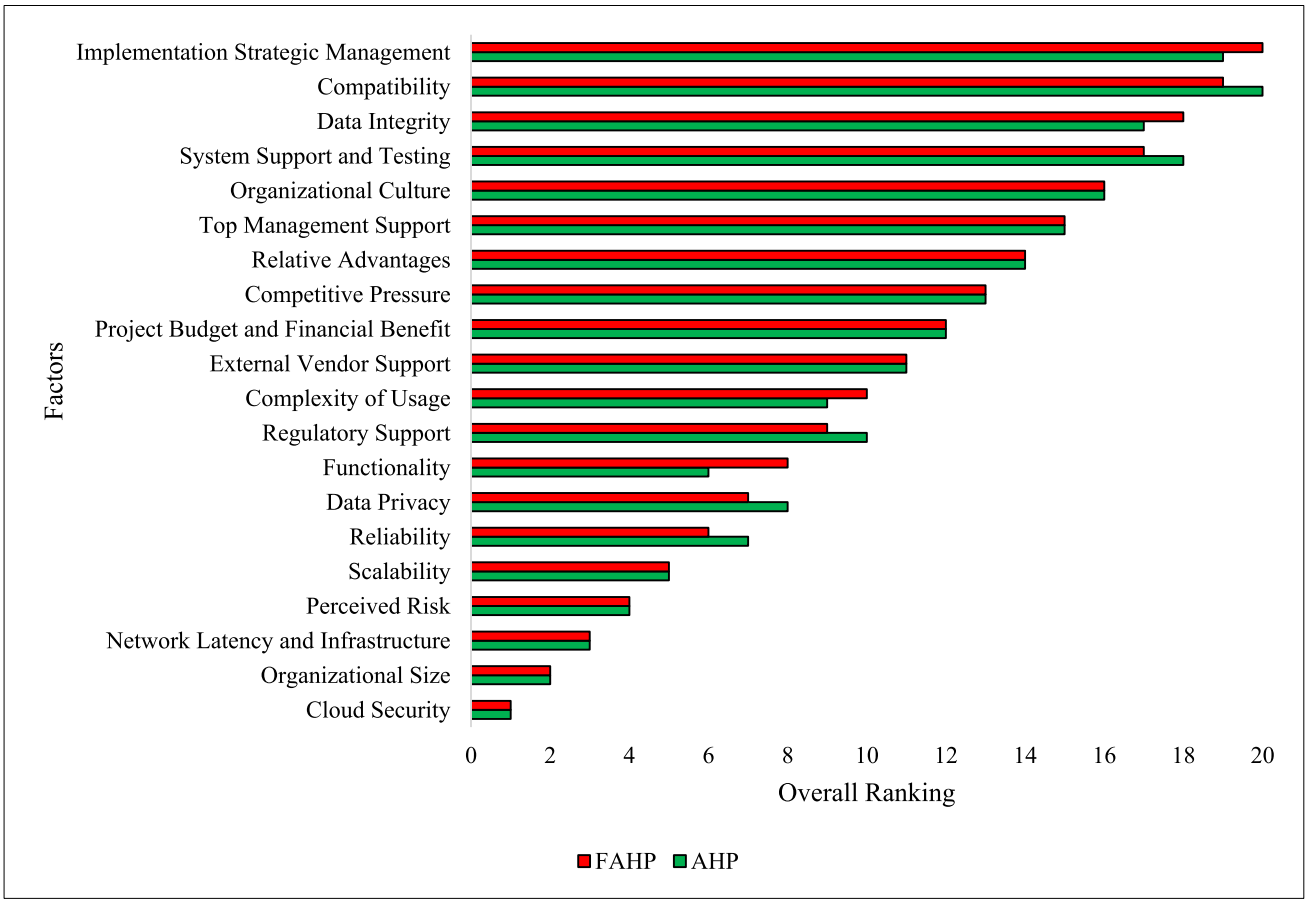

FIGURE 7. Overall ranking of factors using AHP and FAHP.

TABLE 15. TFN scale.

Linguistics scale for importance	Triangular fuzzy scale	Triangular fuzzy reciprocal scale
Equally Importance (EI)	$\left(\frac{1}{2},1,\frac{3}{2}\right)$	$\left(\frac{2}{3},1,2\right)$
Weakly more importance (WMI)	$\left(1,\frac{3}{2},2\right)$	$\left(\frac{1}{2},\frac{2}{3},1\right)$
Strongly more importance (SMI)	$\left(\frac{3}{2},2,\frac{5}{2}\right)$	$\left(\frac{2}{5},\frac{1}{2},\frac{2}{3}\right)$
Very strongly more importance (VSMI)	$\left(2,\frac{5}{2},3\right)$	$\left(\frac{1}{3},\frac{2}{5},\frac{1}{2}\right)$
Absolutely more importance (AMI)	$\left(\frac{5}{2},3,\frac{7}{2}\right)$	$\left(\frac{2}{7},\frac{1}{3},\frac{2}{5}\right)$

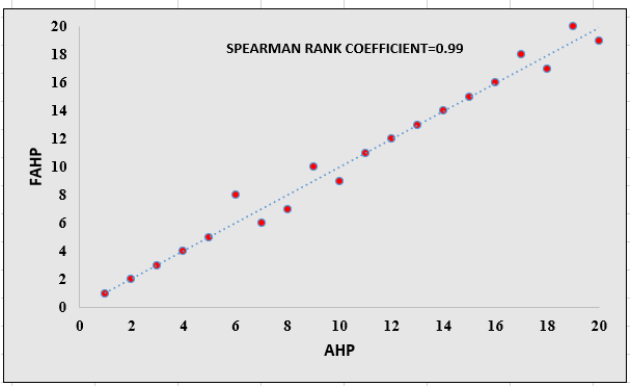

FIGURE 8. Spearman rank coefficient for both methods (AHP & FAHP).

role in CERP success. The influence of Top five CSFs of the CERP found through AHP are Top Management Support, 0.1946 > Cloud Security, 0.1352 > Implementation Strategic Management, 0.1113 > Network Latency and Infrastructure, 0.1056 > Relative Advantages, 0.0962, where '>' indicate the preference over other. The Spearman global rank coefficient is calculated to compare the variation of the results of the two methods as shown in Figure 8. The value −1 indicates a near-perfect negative connotation of ranks and +1 indicates a near-perfect positive connotation of ranks. Zero will indicate no connotation between the ranks. The closer the value is to zero, the weaker is the association between the ranks. The graph clearly shows the nearly perfect positive connotation of ranks by both methods.

The administrative managers face a dilemma while selecting ERP/CERP systems for the organizations. The present

TABLE 16. Pairwise comparison of the dimensions of cloud ERP using FAHP.

	CE	TA	IA	EI	OB	Weightages
Cloud ERP Essentials (CE)	(1,1,1)	(1,2,3)	(3,4,5)	(3,4,5)	$\left(\frac{1}{3},\frac{1}{2},1\right)$	0.2767
Technological Advancement (TA)	$\left(\frac{1}{3},\frac{1}{2},1\right)$	(1, 1, 1)	(2,3,4)	(3,4,5)	$(\frac{1}{4},\frac{1}{3},\frac{1}{2})$	0.1846
Innovational Ideas (II)	$\left(\frac{1}{5},\frac{1}{4},\frac{1}{3}\right)$	$\left(\frac{1}{4},\frac{1}{3},\frac{1}{2}\right)$	(1,1,1)	(2,3,4)	$\left(\frac{1}{5},\frac{1}{4},\frac{1}{3}\right)$	0.0905
Environmental Impact (EI)	$\left(\frac{1}{5},\frac{1}{4},\frac{1}{3}\right)$	$\left(\frac{1}{5},\frac{1}{4},\frac{1}{3}\right)$	$\left(\frac{1}{4},\frac{1}{3},\frac{1}{2}\right)$	(1,1,1)	$\left(\frac{1}{6},\frac{1}{5},\frac{1}{4}\right)$	0.0526
Organizational Behavior (OB)	(1,2,3)	(2,3,4)	(3,4,5)	(4,5,6)	(1,1,1)	0.3957

TABLE 17. Composite rank and weight of CERP Dimension using FAHP.

Cloud ERP Dimensions	Dimension Weightage	Factors of Cloud ERP	Criteria Weights		FAHP Ranking
			Local	Global	
Cloud ERP Essentials (CE)	0.2766	Cloud Security	0.4888	0.1352	2
		Data Privacy	0.1047	0.0290	10
		Relative Advantages	0.3475	0.0962	5
		Perceived Risk	0.0590	0.0163	16
Technological Advancement (TA)	0.1845	Network Latency and Infrastructure	0.5720	0.1056	4
		Data Integrity	0.1116	0.0206	13
		System Support and Testing	0.2612	0.0482	7
		Scalability	0.0552	0.0102	18
Innovational Ideas (II)	0.0905	Functionality	0.5793	0.0524	6
		Compatibility	0.2546	0.0230	12
		Complexity of Usage	0.0483	0.0044	19
		Reliability	0.1179	0.0107	17
Environmental Impact (EI)	0.0525	Competitive Pressure	0.0806	0.0042	20
		Regulatory Support	0.3567	0.0187	14
		External Vendor Support	0.5627	0.0296	9
Organizational Behavior (OB)	0.3956	Top Management Support	0.4919	0.1946	1
		Organizational Size	0.0422	0.0167	15
		Organizational Culture	0.0633	0.0250	11
		Implementation Strategic Management	0.2812	0.1113	3
		Project Budget and Financial Benefit	0.1214	0.0481	8

TABLE 18. Synthesized weight comparison and ranking of cloud ERP dimensionS and CSFs using AHP-GDM and FAHP.

Cloud ERP Dimensions	Dimension Weightage		Factors	Local Weights		Global Weights		Overall Ranking	
	AHP	FAHP		AHP	FAHP	AHP	FAHP	AHP	FAHP
Cloud ERP Essentials (CE)	0.2826	0.2766	CS	0.4871	0.4888	0.1377	0.1352	2	2
			DP	0.1051	0.1047	0.0297	0.0290	9	10
			RA	0.3468	0.3475	0.0980	0.0962	5	5
			PR	0.0610	0.0590	0.0172	0.0163	16	16
Technological Advancement (TA)	0.1821	0.1845	NLI	0.5820	0.5720	0.1060	0.1056	4	4
			DI	0.1119	0.1116	0.0204	0.0206	13	13
			SST	0.2509	0.2612	0.0457	0.0482	8	7
			SC	0.0551	0.0552	0.0100	0.0102	17	18
Innovational Ideas (II)	0.0849	0.0905	FU	0.5852	0.5793	0.0497	0.0524	7	6
			CO	0.2504	0.2546	0.0213	0.0230	12	12
			CU	0.0500	0.0483	0.0042	0.0044	20	19
			RE	0.1144	0.1179	0.0097	0.0107	18	17
Environmental Impact (EI)	0.0525	0.0525	CP	0.0837	0.0806	0.0044	0.0042	19	20
			RS	0.3567	0.3567	0.0187	0.0187	14	14
			EVS	0.5596	0.5627	0.0294	0.0296	10	9
Organizational Behavior (OB)	0.3980	0.3956	TMS	0.4878	0.4919	0.1941	0.1946	1	1
			OS	0.0450	0.0422	0.0179	0.0167	15	15
			OC	0.0601	0.0633	0.0239	0.0250	11	11
			SM	0.2816	0.2812	0.1121	0.1113	3	3
			PBF	0.1255	0.1214	0.0499	0.0481	6	8

findings will help administrative managers to take robust decisions in selecting ERP/CERP systems to suit the need of the organization. The administrative managers will be in a position to use these models to make a procurement decision wisely.

V. LIMITATIONS AND SCOPE FOR FUTURE WORK

The Dimensions and CSFs are important in the selection of the CERP system for any organization hence due care must be taken while modeling them for required objectives. The smooth and effective implementation of the CERP system

may be carried out by controlling the Dimensions and CSFs. The priority and ranking of CSFs of CERP obtained can be generalized with various degrees of acceptance. The present research adopted the MCDM approach and used a limited number of DMs for AHP and FAHP. A broad DMs group can be used in future studies. The weight and rank of CSFs of the CERP may be evaluated using other MCDM approaches.

VI. CONCLUSION

Organizations witness the increasing use of information technology, internet speed, and electronic communication in today's business. The organization also feel the pressure of the local and global competition hence to combat such pressure organization has to rely on new tracking-tracing and information exchanges system like CERP to improve information flow, material flow and financial flow. However, the CERP selection may pose a great risk to organizations opting for the CERP system. Further, CERP implementation also needs a deep understanding of the process hence organization must follow the standard implementation guidelines for its successful implementation. Due care must be taken while selecting and implementing the CERP system. The right selection and implementation of the CERP system will be able to cater to the need of all stakeholders which demands the evaluation and ranking of CSFs of CERP. Thus, the evaluation and ranking of CSFs of CERP will help all its stakeholders. The user organization may take full advantage of the CERP system to fulfill their strategic objectives whereas the service providers will get business volume on satisfying the customer demand. The MCDM method like AHP and FAHP provides an easy and systematic methodology to assess the organizational needs for its CERP requirement.

REFERENCES

[1] Y.-M. Cheng, "What drives cloud ERP continuance? An integrated view," *J. Enterprise Inf. Manage.*, vol. 31, no. 5, pp. 724–750, Aug. 2018.

[2] S. S. Bhatia and V. Gupta, "Principles and practices for the implementation of cloud based ERP in SMEs," in *Proc. MATEC Web Conf.*, vol. 57, 2016, p. 2010.

[3] B. K. Muslmani, S. Kazakzeh, E. Ayoubi, and S. Aljawarneh, "Reducing integration complexity of cloud-based ERP systems," in *Proc. 1st Int. Conf. Data Sci., E-Learn. Inf. Syst.*, Oct. 2018, pp. 1–6.

[4] S. Gupta, R. Meissonier, V. A. Drave, and D. Roubaud, "Examining the impact of cloud ERP on sustainable performance: A dynamic capability view," *Int. J. Inf. Manage.*, vol. 51, Apr. 2020, Art. no. 102028.

[5] S. Gupta, S. C. Misra, N. Kock, and D. Roubaud, "Organizational, technological and extrinsic factors in the implementation of cloud ERP in SMEs," *J. Organizational Change Manage.*, vol. 31, no. 1, pp. 83–102, Feb. 2018.

[6] N. M. Alsharari, M. Al-Shboul, and S. Alteneiji, "Implementation of cloud ERP in the SME: Evidence from UAE," *J. Small Bus. Enterprise Develop.*, vol. 27, no. 2, pp. 299–327, Mar. 2020.

[7] V. Gupta and S. S. Bhatia, "Cloud computing: An operational framework in the implementation of ERP," *Int. J. Adv. Res. Comput. Sci. Softw. Eng.*, vol. 7, no. 2, pp. 164–169, Feb. 2017.

[8] S. Das and M. Dayal, "Exploring determinants of cloud-based enterprise resource planning (ERP) selection and adoption: A qualitative study in the Indian education sector," *J. Inf. Technol. Case Appl. Res.*, vol. 18, no. 1, pp. 11–36, Mar. 2016.

[9] A. M. AlBar and M. R. Hoque, "Determinants of cloud ERP adoption in Saudi Arabia: An empirical study," in *Proc. Int. Conf. Cloud Comput. (ICCC)*, Apr. 2015, pp. 1–4.

[10] H. Alhanatleh and M. Akkaya, "The investigation of Jordanian education ministry employees attitude toward the using of cloud ERP," *Int. J. Commun. Netw. Syst. Sci.*, vol. 9, no. 11, p. 440, 2016.

[11] Y.-W. Chang and P.-Y. Hsu, "An empirical investigation of organizations' switching intention to cloud enterprise resource planning: A cost-benefit perspective," *Inf. Develop.*, vol. 35, no. 2, pp. 290–302, Mar. 2019.

[12] R. Sandu and E. Gide, "Technological, organisational and environmental (TOE) factors that influence the adoption of cloud based service SMEs in India," in *Proc. IEEE 11th Int. Conf. Cloud Comput. (CLOUD)*, Jul. 2018, pp. 866–870.

[13] Y.-H. Lee, P. Hsu, Y.-W. Chang, and Y.-S. Cheng, "Integrating TRA and toe frameworks for cloud ERP switching intention by Taiwanese Company," in *Proc. PACIS*, 2016, p. 139.

[14] Q. N. Naveed, A. Muhammad, S. Sanober, M. R. N. Qureshi, and A. Shah, "A mixed method study for investigating critical success factors (CSFs) of e-learning in Saudi Arabian universities," *Methods*, vol. 8, no. 5, pp. 171–178, 2017.

[15] Q. N. Naveed, M. R. N. M. Qureshi, A. Shaikh, A. O. Alsayed, S. Sanober, and K. Mohiuddin, "Evaluating and ranking cloud-based E-learning critical success factors (CSFs) using combinatorial approach," *IEEE Access*, vol. 7, pp. 157145–157157, 2019.

[16] C. López and A. Ishizaka, "GAHPSort: A new group multi-criteria decision method for sorting a large number of the cloud-based ERP solutions," *Comput. Ind.*, vols. 92–93, pp. 12–25, Nov. 2017.

[17] M. H. L., A. O. Mathew, and L. L. R. Rodrigues, "Prioritizing the factors affecting cloud ERP adoption—An analytic hierarchy process approach," *Int. J. Emerg. Markets*, vol. 13, no. 6, pp. 1559–1577, Nov. 2018.

[18] S. V. Bharathi and T. Mandal, "Prioritising and ranking critical factors for sustainable cloud ERP adoption in SMEs," *Int. J. Autom. Logist.*, vol. 1, no. 3, pp. 294–316, 2015.

[19] N. Bhatt, S. Guru, S. Thanki, and G. Sood, "Analysing the factors affecting the selection of ERP package: A fuzzy AHP approach," *Inf. Syst. E-bus. Manag.*, vol. 19, pp. 641–682, Mar. 2021.

[20] A. Muhammad, A. Siddique, Q. N. Naveed, U. Khaliq, A. M. Aseere, M. A. Hasan, M. R. N. Qureshi, and B. Shahzad, "Evaluating usability of academic websites through a fuzzy analytical hierarchical process," *Sustainability*, vol. 13, no. 4, p. 2040, Feb. 2021.

[21] A. K.-J. L. Y. Qian and A. S. Baharudin, "Factors affecting the adoption of enterprise resource planning (ERP) on cloud among small and medium enterprises (SMES) in Penang Malaysia," *J. Theor. Appl. Inf. Technol.*, vol. 88, no. 3, pp. 1–12, Jun. 2016.

[22] A. M. AlBar and M. R. Hoque, "Factors affecting cloud ERP adoption in Saudi Arabia: An empirical study," *Inf. Develop.*, vol. 35, no. 1, pp. 150–164, Jan. 2019.

[23] A. Alkhlewi, R. Walters, and G. Wills, "Success factors for the implementation of a private government cloud in Saudi Arabia," in *Proc. 3rd Int. Conf. Future Internet Things Cloud*, Aug. 2015, pp. 387–390.

[24] G. J. Mohammed and M. A. Burhanuddin, "Conceptual model for adoption cloud-based ERP in SMEs: Case study Iraq," *Int. J. Eng. Technol.*, vol. 7, no. 3.20, pp. 756–758, 2018.

[25] R. R. Ogunrinde, Y. Y. Jusoh, N. C. Pa, W. N. W. A. Rahman, and A. Abdullah, "QoS-based cloud ERP selection model for SMEs," *J. Telecommun. Electron. Comput. Eng.*, vol. 9, nos. 2–4, pp. 21–25, 2017.

[26] S. Gupta and S. C. Misra, "Moderating effect of compliance, network, and security on the critical success factors in the implementation of cloud ERP," *IEEE Trans. Cloud Comput.*, vol. 4, no. 4, pp. 440–451, Oct. 2016.

[27] S. Gupta and S. C. Misra, "Compliance, network, security and the people related factors in cloud ERP implementation," *Int. J. Commun. Syst.*, vol. 29, no. 8, pp. 1395–1419, May 2016.

[28] U. M. Z. Usman, M. N. Ahmad, and N. H. Zakariya, "Factors influencing cloud enterprise resource planning adoption in SMEs," in *Information Science and Applications (ICISA)*. Singapore: Springer, 2016, pp. 235–245.

[29] H. Miss, T. Victoria, K. Tulimevava, and others, "An investigation of factors leading to the reluctance of SaaS ERP adoption in Namibian SMEs," *Afr. J. Inf. Syst.*, vol. 8, no. 4, p. 1, 2016.

[30] U. M. Z. Usman, M. N. Ahmad, and N. H. Zakaria, "Antecedents of cloud ERP adoption in manufacturing industry: Nigerian SMEs context," in *Proc. Knowl. Manage. Int. Conf. (KMICe)*, Chiang Mai, Thailand, Aug. 2016.

[31] T.-M. Lim, A. S.-H. Lee, and M.-K. Yap, "User acceptance of SaaS ERP considering perceived risk, system performance and cost," in *Information Science and Applications (ICISA)*. Singapore: Springer, 2016, pp. 53–63.

[32] T. D. Nguyen and K. V. T. Luc, "Information systems success: Empirical evidence on cloud-based ERP," in *Proc. Int. Conf. Future Data Secur. Eng.*, 2018, pp. 471–485.
[33] R. Baskaran, "An empirical study on determining the critical success factors for the implementation of hybrid cloud ERP system in IT organizations," *Taga J.*, vol. 14, pp. 2505–2528, 2018.
[34] S. Gupta, S. Kumar, S. K. Singh, C. Foropon, and C. Chandra, "Role of cloud ERP on the performance of an organization: Contingent resource-based view perspective," *Int. J. Logistics Manage.*, vol. 29, no. 2, pp. 659–675, May 2018.
[35] Y.-M. Cheng, "A hybrid model for exploring the antecedents of cloud ERP continuance: Roles of quality determinants and task-technology fit," *Int. J. Web Inf. Syst.*, vol. 15, no. 2, pp. 215–235, Jun. 2019.
[36] T. D. Nguyen, T. T. Huynh, U. H. Van, and T. M. Pham, "The role of innovation in cloud-based ERP adoption," in *Proc. IFIP Int. Conf. Comput. Inf. Syst. Ind. Manage.*, 2019, pp. 240–252.
[37] R. Seethamraju, "Adoption of software as a service (SaaS) enterprise resource planning (ERP) systems in small and medium sized enterprises (SMEs)," *Inf. Syst. Frontiers*, vol. 17, no. 3, pp. 475–492, Jun. 2015.
[38] S. Gupta, X. Qian, B. Bhushan, and Z. Luo, "Role of cloud ERP and big data on firm performance: A dynamic capability view theory perspective," *Manage. Decis.*, vol. 57, no. 8, pp. 1857–1882, Sep. 2019.
[39] S. Gupta, S. C. Misra, A. Singh, V. Kumar, and U. Kumar, "Identification of challenges and their ranking in the implementation of cloud ERP: A comparative study for SMEs and large organizations," *Int. J. Qual. Rel. Manage.*, vol. 34 no. 7, pp. 1056–1072, 2017.
[40] M. O. Malik and N. Khan, "Analysis of ERP implementation to develop a strategy for its success in developing countries," *Prod. Planning Control*, vol. 32, no. 12, pp. 1020–1035, 2020.
[41] B. Johansson, A. Alajbegovic, V. Alexopoulo, and A. Desalermos, "Cloud ERP adoption opportunities and concerns: The role of organizational size," in *Proc. 48th Hawaii Int. Conf. Syst. Sci.*, Jan. 2015, pp. 4211–4219.
[42] M. Haddara, A. Fagerstrøm, and B. Mæland, "Cloud ERP systems: Anatomy of adoption factors & attitudes," *J. Enterprise Resource Planning Stud.*, vol. 2015 pp. 1–24, Sep. 2015.
[43] K. Surendro and O. Olivia, "Academic cloud ERP quality assessment model," *Int. J. Electr. Comput. Eng. (IJECE)*, vol. 6, no. 3, p. 1038, Jun. 2016.
[44] G. C. A. Peng and C. Gala, "Cloud ERP: A new dilemma to modern organisations?" *J. Comput. Inf. Syst.*, vol. 54, no. 4, pp. 22–30, Jun. 2014.
[45] S. Gupta and S. C. Misra, "Implementation of cloud ERP–moderating effect of compliance on the organizational factors," in *Proc. 5th Int. Conf. Cloud Comput. Services Sci.*, 2015, pp. 194–198.
[46] T. L. Saaty, "Decision making with the analytic hierarchy process," *Int. J. Services Sci.*, vol. 1, no. 1, pp. 83–98, 2008.
[47] Q. N. Naveed, M. R. N. Qureshi, A. O. Alsayed, A. Muhammad, S. Sanober, and A. Shah, "Prioritizing barriers of E-Learning for effective teaching-learning using fuzzy analytic hierarchy process (FAHP)," in *Proc. 4th IEEE Int. Conf. Eng. Technol. Appl. Sci. (ICETAS)*, Nov. 2017, pp. 1–8.
[48] C. Kahraman, U. Cebeci, and D. Ruan, "Multi-attribute comparison of catering service companies using fuzzy AHP: The case of Turkey," *Int. J. Prod. Econ.*, vol. 87, no. 2, pp. 171–184, 2004.
[49] A. Kauffman and M. M. Gupta, *Introduction to Fuzzy Arithmetic, Theory and Application*. New York, NY, USA: Van Nostrand Reinhold, 1991.
[50] D.-Y. Chang, "Applications of the extent analysis method on fuzzy AHP," *Eur. J. Oper. Res.*, vol. 95, no. 3, pp. 649–655, 1996.

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