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

Quadri Noorulhasan Naveed¹, Saiful Islam², Mohamed Rafik N Qureshi², Ali M. Aseere¹, Mohammed Aref Abdul Rasheed³ and Sadaf Fatima⁴

¹College of Computer Science, King Khalid University, Abha 61413, Saudi Arabia
² College of Engineering, King Khalid University, Abha 61413, Saudi Arabia
³College of Commerce and Business Administration, Dhofar University, Salalah 211, Oman
⁴PhD Research Scholar, Aligarh Muslim University, Aligarh, 202002, India

Corresponding author: Sadaf Fatima (e-mail: sadaf.scholar@gmail.com).

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 sub-criteria factors. 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 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 user in adopting CERP software such as the Diffusion of Innovation (DOI) [7]–[9], Technology Acceptance Model [1], Technology Organization Environment (TOE) [7], [9], [12], [13], 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 study on it. A detailed review of literature for CERP and MCDM based research methodology has been carried out and provides 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 (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 (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]. Quadri (2019) investigated the CSFs of Cloud-based E-Learning and employed AHP in the crisp and fuzzy environment for subsequent evaluating and ranking [15]. Nityesh (2021) Investigated and ranked several factors touching ERP adoption decision for SMEs, explicitly in the context of Indian market with the help of 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 dimension and CSFs of CERP are very significant in identifying and adopting the CERP system for any 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 of 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.

![FIGURE 1. MULTI-PHASES LITERATURE-BASED FRAMEWORK FOR CERP](image)

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 I provides Dimensions and CSFs of CERP.

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

2) TECHNOLOGICAL ADVANCEMENT

Many researchers considered Technological Advancement as an important Dimension 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 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 II.

| Dimensions                  | CSFs                          | References |
|-----------------------------|-------------------------------|------------|
| 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] |

3) INNOVATIONAL IDEAS

Innovational Ideas for any CERP needs 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 (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 III presents the Dimension and CSFs related to the Innovational Ideas.
TABLE III
FACTORs RELATED TO INNOVATIONAL IDEAS

| 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] |
| Reliability (RE)         | [43], [8], [24], [21], [23] |

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 IV presents the Dimension and CSFs related to the Environmental.

TABLE IV
FACTORs RELATED TO ENVIRONMENTAL IMPACT

| Competitive Pressure (CP) | [12], [21], [7], [22], [26], [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] |

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], [28] and [30] listed the most potent acceptance CERP factors such as Top Management Support, Compatibility, Budget for technology readiness in SMEs. Table V presents the Dimension and CSFs related to Organizational Behaviour.

TABLE V
FACTORs RELATED TO ORGANIZATIONAL BEHAVIOUR

| 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] |

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 provide more range in a pairwise comparison. Thus FAHP helps in providing more accuracy in the decision-making.

1) AHP METHODOLOGY

\[
A = \begin{bmatrix}
C_{11} & \cdots & C_{1n} \\
\vdots & \ddots & \vdots \\
C_{m1} & \cdots & C_{mn}
\end{bmatrix}
\]

(1)

\[
C_{ii} = 1, C_{ij} = \frac{1}{C_{ji}}, C_{ij} \neq 0
\]

(2)

Where the Dimension or CSF may be represented by \(C_1, C_2, \ldots, C_{mn}\). The Saaty’s scale [2] as shown in Table VI may be used to provide relative importance between two Dimensions or CSFs.

TABLE VI
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 |

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 VII shows a random index for a given \(n\).

\[
CR = \frac{CI}{RI}
\]

(3)

\[
CI = (\lambda_{max} - n) / (n - 1)
\]

(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 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:

i) 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.

![Figure 2 Triangular fuzzy number Q](image)

The various arithmetic operations may be performed using fuzzy numbers [49], considering fuzzy numbers \(Q_1 = (l_1, m_1, n_1)\) and \(Q_2 = (l_2, m_2, n_2)\). A various arithmetic operation like subtraction, addition, division, and multiplication can be performed using various equations (6-10):

\[
Q_1 \oplus Q_2 = (l_1 + l_2, m_1 + m_2, n_1 + n_2)
\]

(6)

\[
Q_1 \ominus Q_2 = (l_1 - l_2, m_1 - m_2, n_1 - n_2)
\]

(7)

\[
Q_1 \otimes Q_2 = (l_1l_2, m_1m_2, n_1n_2)
\]

(8)

\[
\lambda \otimes Q_1 = (\lambda l_1, \lambda m_1, \lambda n_1)
\]

(9)

\[
Q_1^{-1} = \left(\frac{1}{n_1}, \frac{1}{m_1}, \frac{1}{l_1}\right)
\]

(10)

ii) 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. \(Y = \{y_1, y_2, \ldots, y_k\}\) and \(Z = \{z_1, z_2, \ldots, z_n\}\) 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:

\[
Q_{gi}^1, Q_{gi}^2, \ldots, Q_{gi}^f, i = 1, 2, \ldots, n
\]

(11)

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 Dimension s 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

\[
F_i = \sum_{j=1}^{m} Q_{gi}^j \otimes \left[\sum_{i=1}^{n} \sum_{j=1}^{m} Q_{gi}^j\right]^{-1}
\]

(12)

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

| TABLE VII |
|-----------|
| **RANDOM INDEX** |
| \(n\) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Random Index | 0 | 0.58 | 0.9 | 1.12 | 1.24 | 1.32 | 1.41 | 1.45 | 1.49 |
\[ \sum_{j=1}^{f} Q_{gl}^j = \left( \sum_{j=1}^{f} l_j, \sum_{j=1}^{f} m_j, \sum_{j=1}^{f} n_j \right) \]  

(13)

and \[ \left[ \sum_{j=1}^{n} Q_{gl}^j \right]^{-1} \] gives the fuzzy summation of \[ Q_{gl}^j \] values are calculated as

\[ \sum_{i=1}^{n} l_i \quad \sum_{i=1}^{n} m_i \quad \sum_{i=1}^{n} n_i \]

(14)

The inverse of the vector may be obtained as:

\[ \left[ \sum_{i=1}^{n} Q_{gl}^i \right]^{-1} \]

(15)

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

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

(16)

and can be represented as:

\[ V(Q_2 \geq Q_1) = \mu_{Q_2}(f) \]

(17)

\[ \mu_{Q_2}(f) = \begin{cases} 
0 & \text{if } m_2 \geq m_1 \\
1 & \text{if } l_2 \geq n_2 \\
\frac{m_2 - m_1}{n_2 - n_1} & \text{otherwise}
\end{cases} \]

(18)

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, \( \tilde{A}_h = \{ \tilde{q}_{ijh} \} \), where \( \tilde{A}_h = (l_{ijk}, m_{ijk}, u_{ijk}) \) represents the relative importance of element \( i \) to \( j \) as derived by DM \( k \). The aggregation may be obtained using Equation (19).

\[ l_{ij} = \min(l_{ijk}), k = 1,2, \ldots, k \]

\[ m_{ij} = \frac{k}{\prod_{k=1}^{k} m_{ijk}} \]

\[ n_{ij} = \max(u_{ijk}), h = 1,2, \ldots, k \]

(19)

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 \( \mu_{Q_1} \) and \( \mu_{Q_2} \) denoted as \( Q \). Thus \( Q_1 \) and \( Q_2 \) maybe calculated through the values of \( V(Q_1 \geq Q_2) \) and \( V(Q_2 \geq Q_1) \).

**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 maybe 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 consisting of four Dimensions and twenty-four CSFs identified using the 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 VI-X. 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 XI 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 XII.

![Figure 4. Framework for Ranking CERP Dimensions and Factors](image)

### Table VIII

| CERP Dimensions (CE) | TA | II | EI | OB | Weightages |
|----------------------|----|----|----|----|------------|
| Cloud ERP Essentials (CE) | 1 | 3 | 5 | 7 | 1 | 0.3084 |
| Technological Advancement (TA) | 1 | 1 | 5 | 7 | 3 | 0.1870 |
| Innovational Ideas (II) | 5 | 1 | 1 | 5 | 1 | 0.0657 |
| Environmental Impact (EI) | 7 | 3 | 5 | 1 | 1 | 0.0348 |
| Organizational Behavior (OB) | 2 | 3 | 5 | 7 | 1 | 0.4042 |

\[ \lambda_{\text{max}} = 5.3275, \ CR = 0.0728, \ CI = 0.0819, \ RI = 1.12 \]

### Table IX

| CERP Dimensions (CE) | TA | IA | EI | OB | Weightages |
|----------------------|----|----|----|----|------------|
| Cloud ERP Essentials (CE) | 1 | 5 | 7 | 5 | 1 | 0.3521 |
| Technological Advancement (TA) | 1 | 1 | 2 | 5 | 1 | 0.1166 |
| Innovational Ideas (II) | 7 | 5 | 3 | 1 | 1 | 0.0823 |
| Environmental Impact (EI) | 5 | 3 | 5 | 5 | 1 | 0.0404 |
| Organizational Behavior (OB) | 2 | 5 | 3 | 7 | 1 | 0.4086 |

\[ \lambda_{\text{max}} = 5.4465, \ CR = 0.0993, \ CI = 0.1116, \ RI = 1.12 \]

### Table X

| CERP Dimensions (CE) | TA | IA | EI | OB | Weightages |
|----------------------|----|----|----|----|------------|
| Cloud ERP Essentials (CE) | 1 | 3 | 5 | 3 | 1 | 0.2741 |
| Technological Advancement (TA) | 3 | 3 | 1 | 3 | 1 | 0.1645 |
| Innovational Ideas (II) | 7 | 5 | 3 | 1 | 1 | 0.0980 |
| Environmental Impact (EI) | 5 | 3 | 7 | 1 | 1 | 0.0581 |

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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 XIII have been used in attaining the weights for the CERP Dimensions and its Factors. The systematic research methodology as illustrated in the previous section has been pursued to determine the weights. Table XIV shows the weights after the pairwise comparison of the CERP Dimensions of using FAHP. Table XV 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 XVI. 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.

| Dimensions          | Local Weights | Global Weights | AHP Ranking |
|---------------------|---------------|----------------|-------------|
| Cloud ERP Essentials (CE) | 0.4871        | 0.1377         | 2           |
|                     | 0.1051        | 0.0297         | 9           |
|                     | 0.3468        | 0.0980         | 5           |
|                     | 0.0610        | 0.0172         | 16          |
| 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          |
| Functional          | 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          |
| Competitive Pressure | 0.0837        | 0.0044         | 19          |
| Regulatory Support  | 0.3567        | 0.0187         | 14          |
| External Vendor Support | 0.5596       | 0.0294         | 10          |
| 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           |

| Linguistics scale for importance | Triangular fuzzy scale | Triangular fuzzy reciprocal scale |
|----------------------------------|------------------------|----------------------------------|
| Equally Importance (EI)         | \( \frac{1}{3}, \frac{1}{2} \) | \( \frac{2}{3}, 1, 2 \) |
| Weakly more importance (WMI)    | \( \frac{1}{3}, 2, \frac{2}{3} \) | \( \frac{1}{2}, 3, 1 \) |
| Strongly more importance (SMI)  | \( \frac{1}{3}, \frac{2}{3}, 1 \) | \( \frac{2}{3}, 1, 2 \) |
| Very strongly more importance (VSMI) | \( \frac{5}{2}, \frac{1}{3}, \frac{2}{3} \) | \( \frac{1}{3}, \frac{2}{3}, 2 \) |
| Absolutely more importance (AMI) | \( \frac{5}{2}, \frac{7}{2}, \frac{2}{3} \) | \( \frac{2}{3}, \frac{1}{2}, 2 \) |
TABLE XVI
PAIRWISE COMPARISON OF THE DIMENSIONS OF CLOUD ERP USING FAHP

| Dimension                          | CE         | TA         | IA         | EI         | Weightages |
|------------------------------------|------------|------------|------------|------------|------------|
| Cloud ERP Essentials (CE)          | (1, 1, 1)  | (1, 2, 3)  | (3, 4, 5)  | (3, 4, 5)  | 0.2767     |
| Technological Advancement (TA)     | \(\begin{pmatrix} 1 & 1 & -1 \\ 1 & 2 & 3 \end{pmatrix}\) | (1, 1, 1)  | (2, 3, 4)  | (3, 4, 5)  | 0.1846     |
| Innovational Ideas (II)            | \(\begin{pmatrix} 1 & 1 & 1 \\ 5 & 4 & 3 \end{pmatrix}\) | \(\begin{pmatrix} 1 & 1 & 1 \\ 4 & 3 & 2 \end{pmatrix}\) | (1, 1, 1)  | (2, 3, 4)  | 0.0905     |
| Environmental Impact (EI)          | \(\begin{pmatrix} 1 & 1 & 1 \\ 5 & 4 & 3 \end{pmatrix}\) | \(\begin{pmatrix} 1 & 1 & 1 \\ 5 & 4 & 3 \end{pmatrix}\) | (1, 1, 1)  | (2, 3, 4)  | 0.0526     |
| Organizational Behavior (OB)       | (1, 2, 3)  | (2, 3, 4)  | (3, 4, 5)  | (4, 5, 6)  | 0.3957     |

TABLE XVII
COMPOSITE RANK AND WEIGHT OF CERP DIMENSION USING FAHP

| Cloud ERP Dimensions | Dimension Weightage | Criteria Weights | Factors of Cloud ERP | FAHP Ranking |
|----------------------|---------------------|------------------|----------------------|--------------|
| Cloud ERP Essentials (CE) | 0.2766             |                  | Cloud Security       | 0.4888       |
|                      |                     |                  | Data Privacy         | 0.1047       |
|                      |                     |                  | Relative Advantages  | 0.3475       |
|                      |                     |                  | Perceived Risk       | 0.0590       |
| Technological Advancement (TA)   | 0.1845             |                  | Network Latency and Infrastructure | 0.5720       |
|                      |                     |                  | Data Integrity       | 0.1116       |
|                      |                     |                  | System Support and Testing | 0.2612       |
|                      |                     |                  | Scalability          | 0.0552       |
| Innovational Ideas (II)         | 0.0905             |                  | Functionality        | 0.5793       |
|                      |                     |                  | Compatibility        | 0.2546       |
|                      |                     |                  | Complexity of Usage  | 0.0483       |
|                      |                     |                  | Reliability          | 0.1179       |
| Environmental Impact (EI)       | 0.0525             |                  | Competitive Pressure | 0.0806       |
|                      |                     |                  | Regulatory Support   | 0.3567       |
|                      |                     |                  | External Vendor Support | 0.5627       |
| Organizational Behavior (OB)    | 0.3956             |                  | Top Management Support | 0.4919       |
|                      |                     |                  | Organizational Size  | 0.0422       |
|                      |                     |                  | Organizational Culture | 0.0633       |
|                      |                     |                  | Implementation Strategic Management | 0.2812       |
|                      |                     |                  | Project Budget and Financial Benefit | 0.1214       |
### TABLE XVIII
SYNTHESIZED WEIGHT COMPARISON AND RANKING OF CLOUD ERP DIMENSION 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        |
| 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             |
Figure 5. Weightages of Dimensions

- Organizational Behavior (OB)
- Cloud ERP Essentials (CE)
- Technological Advancement (TA)
- Innovational Ideas (II)
- Environmental Impact (EI)

Figure 6. Weightages of Factors

- Functionality
- Network Latency and Infrastructure
- External Vendor Support
- Top Management Support
- Cloud Security
- Regulatory Support
- Relative Advantages
- Implementation Strategic Management
- System Support and Testing
- Compatibility
- Project Budget and Financial Benefit
- Reliability
- Data Integrity
- Data Privacy
- Competitive Pressure
- Perceived Risk
- Organizational Culture
- Scalability
- Complexity of Usage
- Organizational Size

Legend:
- Global Weight FAHP
- Global Weight AHP
- Local Weight FAHP
- Local Weight AHP
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 selection of CERP for any organization so that administrative manager can buy an appropriate ERP/CERP system for the organization. The selected ERP/CERP system must be in a position to cater 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 > 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. The 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 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 dilemma while selecting ERP/CERP systems for the organizations. The present findings will help administrative managers to take robust decision 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 procurement decision wisely.

![Figure 8. Spearman Rank Coefficient for both methods (AHP & FAHP)](image)

**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 improved 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.

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QUADRI NOORULHASAN NAVEED received a Ph.D. degree in information technology from the Department of Information Systems, Kulliyyah of Information and Communication Technology (KICT), International Islamic University Malaysia (IIUM), Kuala Lumpur. He has worked as an IT Engineer with Saudi Aramco and Bank Riyad of Saudi Arabia. He is currently teaching with the College of Computer Science, King Khalid University, Saudi Arabia. His research interests include e-learning, m-learning, cloud computing, cloud-based E-learning systems, and technology-enhanced learning. He has many publications in refereed/indexed international journals and the IEEE, ACM, and Scopus-Springer sponsored conferences. He is also a Reviewer and an International Advisory Board of several conferences and journals. He can be reached through www.qnaveed.com.

SAIFUL ISLAM is working as a Lecturer in the Civil Engineering Department, College of Engineering, King Khalid University, Abha, Kingdom of Saudi Arabia. He did his M.Tech degree from the Indian Institute of Technology, Roorkee. He has completed his B.Tech degree from Zakir Hussain College of Engineering, A.M.U. Aligarh. He is a life member of the Indian Society of Technical Education, the International Association of Protective Structures. He has published several papers in an international journal. His research interests include Slope stability, Natural Hazards, Water Resource Management, Renewable energy, Hydrological modeling.

Mohammed Aref Abdul Rasheed was born in India in 1976. He received the M.Sc. in Computer Science from Dr. Babasaheb Ambedkar Marathwada University, India, in 2000, and the Ph.D. degree in Computer Science from Dr. Babasaheb Ambedkar Marathwada University, India, in 2010. From 2000 to 2006, he was Lecturer at Maulana Azad College of Arts, Science and Commerce, India. From 2006 to 2007, he was a Lecturer at Salalah College of Technology, Salalah, Oman. He is currently an Assistant Professor of MIS at Dhofar University, Salalah Oman. His research has been concerned with Artificial Intelligence and Knowledge Management.

Mohammed Aref Abdul Rasheed was born in India in 1976. He received the M.Sc. in Computer Science from Dr. Babasaheb Ambedkar Marathwada University, India, in 2000, and the Ph.D. degree in Computer Science from Dr. Babasaheb Ambedkar Marathwada University, India, in 2010. From 2000 to 2006, he was Lecturer at Maulana Azad College of Arts, Science and Commerce, India. From 2006 to 2007, he was a Lecturer at Salalah College of Technology, Salalah, Oman. He is currently an Assistant Professor of MIS at Dhofar University, Salalah Oman. His research has been concerned with Artificial Intelligence and Knowledge Management.

SAIFUL ISLAM is working as a Lecturer in the Civil Engineering Department, College of Engineering, King Khalid University, Abha, Kingdom of Saudi Arabia. He did his M.Tech degree from the Indian Institute of Technology, Roorkee. He has completed his B.Tech degree from Zakir Hussain College of Engineering, A.M.U. Aligarh. He is a life member of the Indian Society of Technical Education, the International Association of Protective Structures. He has published several papers in an international journal. His research interests include Slope stability, Natural Hazards, Water Resource Management, Renewable energy, Hydrological modeling.

ALI ASEERE received his Ph.D. degree in Computer Science from the University of Southampton of the United Kingdom in 2012. He has published many research papers in refereed international journals, conference proceedings, and books. He is heading the Computer Science department and holding the Dean position of the College of Computer Science at King Khalid University, KSA. He has served as session chair and organizing committee member of various conferences. His research areas are Intelligent and Multi-Agent Systems, Agent-based models, Agent mining and Image Processing.

SADA FATIMA is a research scholar from the Department of Business Administration, Faculty of Management Studies and Research, Aligarh Muslim University, Aligarh, India. She has earned an MBA degree from the same University. Her specialization is HRM and Finance. She has attended conferences and presented as well as published many papers in refereed journals. Her areas of interest are Organizational Behavior, Organizational Development, SHRM and HRM.

MOHAMED RAFIK NOOR MOHAMED QURESHI received the M.E. degree from the M.S.University of Baroda, and the Ph.D. degree from the Indian Institute of Technology, Roorkee. He has published over 150 articles in journals and conference proceedings at national and international levels. He has guided nine students for their Ph.D. He has participated in more than 30 seminars/conferences at national and international levels. He was a recipient of the Best Ph.D. Thesis Award for his research work. He is a ‘Certified Assessor’ for NVQ from the EMTA Awards Ltd. He is a fellow member and a certified chartered engineer of the Institution of Engineers (India). He is on the editorial panel and a reviewer of reputed international journals.