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TECHNOLOGY ENABLED INTELLIGENT SOLUTION IN HUMAN RESOURCE MANAGEMENT FOR SMART CITIES

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Abstract. The foundation of smart cities is based on an autonomous and decentralized architecture, which consists of sophisticated information and communication technologies (ICT) in convergence with technology enabled solution to improve the business management process in industry 4.0. This study tends to examine the adoption of blockchain technologies (DLT) in the human resource management (HRM) of organizations in building solutions for IOT (Internet of things) smart cities.

The current study explores a unique set of factors selected from the extensive literature and acquired information from fifteen experts having significant experience of blockchain technology in their respective organizations. An integrated fuzzy analytic hierarchy process (F-AHP) is applied to prioritize the identified success factors. Further, the modified decision-making trial and evaluation laboratory (M-DEMATEL) method is utilized to represent the complicated causal relationships among different sub-factors on blockchain-HRM integration.

The findings show the application of blockchain will foster a paradigm change in IOT based smart communities, where recruiters verify the candidate credentials including education, skills, and work experience. The payroll managers would determine the more effective way to make work less complex and moderate, enabling timelier payments to global employees. Furthermore, DLT would enhance the employee learning records and update the real-time information in HRM database technologies. Thus, providing a detailed guide for future Industry 4.0 developers about how blockchain can improve the next generation of industrial applications.

The developed method can help the decision-makers and provide a foundational view to examine the benefits of implementing blockchain technology in the HRM setting of an organization before they choose to integrate in order to enhance Industry 4.0 technologies.

This research will be a novel attempt to synthesize the key factors and subfactors about technology enabled solution within the intelligent HRM process, shedding light to rethink HRM strategies to incorporate blockchain technology in organizations.

Key words: Blockchain Technology (BCT), Human Resource Management (HRM), Distributed Ledger Technology (DLT), Fuzzy AHP (F-AHP), Modified DEMATEL (M-DEMAEL)

1. Introduction. With the ubiquitous implementation of the Internet of things (IOT) and numerous Industry 4.0-based applications such as cloud computing (CC), the Internet of services (IOS), cyber-physical systems (CPS), and data analysis techniques have created an interconnected world in which sensors and actuators perceive, compute, and transfer data to automate the industrial network in smart city. These advanced technologies provide countless intelligent solutions for boosting automation, efficiency, security, precision, and scalability in a variety of industrial and business segments. Blockchain technology is considered an extensive innovative synergist revolutionizing the structure of interaction, creation or valuation between businesses, customers, societies, partners, and individuals [1]. According to the world economic forum predictive analysis, 10% of the global GDP would be on hybrid blockchain technologies by 2025. Gartner [2] determines that blockchain monetary worth will exceed $3.1tn by 2030. There are various companies like Google, Amazon, Facebook, and IBM that are leveraging the blockchain in their core processes to deliver valuable solutions to their clients and employees [3, 4] .

Blockchain is an emerging technology that adds significant value in the HRM domain and streamlines various activities of HR professionals. Human resource management is the most integral component of the organizations entangled with coordinating substantial tasks varying from recruiting and retaining the best talent, processing payroll, regulatory compliance reporting, providing a safe working environment, activating training & development programs, and offering enormous incentives to achieve organizational objectives [5]. Blockchain-based applications will proliferate the human resource industry with immense benefits, that will

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allow organizations and firms to develop and host HR-related activities on the blockchain. Blockchain networks can serve as an imperative instrument for the verification of individual identities, educational background checks, and employment histories, thus leading to attract quality talent for the job position [6]. Additionally, BCT has the potential to provide real-time verification of cross-border payments, without the need for intermediaries such as banks, third parties and clearinghouses, thus workers can be paid instantly with the use of smart contracts [7].There is also a possibility that the performance appraisal model associated with rewards, recognition and salary increments can be re-designed with the distributed ledger platform in an organization [8].Thus, shifting the conventional role to a more strategic role leading the HRM core functions with more realistic and valuable decision support information.

The functioning of HRM in organizations utilising Industry 4.0-supported technical initiatives creates the research gap in the existing system. Thus, HRM system optimization, facilitated by cutting-edge technologies like blockchain promoting the flexibility and agility for improving HRM core activities [9]. Consequently, this research contributes to the organization's HRM domain by addressing the following questions:

RQ1: What are the prominent determinant and sub-determinant for blockchain implementation to enhance the human resource management functions of an organization?

RQ2: How are the stated factors prioritized for the integration of blockchain with HRM practices?

RQ3: How are the selected determinants and sub-determinants interrelated for improving HRM practices through the usage of blockchain?

To resolve abovementioned research questions, this paper attempts to implement an integrated Fuzzy Analytic Hierarchical process and modified DEMATEL methodology to determine critical success factors and sub-factors to uncover their applicability. The objective is to establish an interpretive structural model representing significant success factors while simulating technology based solution using fuzzy approach. Thus, this paper contributes to explore the opportunities regarding the deployment and usage of blockchain technology, particularly for the HRM sector in the smart city to build sustainable HRM ecosystem(services).

2. Literature Review.

2.1. Theoretical foundation. The Information system (IS) adoption literature has been developed by several researchers such as the Innovation Diffusion Theory (IDT), and Technology Acceptance Model (TAM), which have been instrumental in describing the adoption of a variety of IS in their corresponding organizational work [10]. According to the recent challenges faced by HR managers/consultants, the core construct of the unified theory of acceptance and use of Technology (UTAUT) includes behavioural intention to use the technology in the organizational setting [11]. The main determinant of the model is performance expectancy, effort expectancy, social influences and promotion conditions in predicting the user's intention toward blockchain implementation [12]. UTAUT was further modified to include more contextual factors, such as price value, habit, and hedonic motivation thus forming UTAUT2 [13]. The expansion of UTAUT2 provides a foundation for precisely analyzing the adoption and use of emerging blockchain technologies in HRM [14, 15]. This theoretical framework serves as guidance (underpinning theory) for the evolution of research propositions in blockchain technology to be applied in human resource management functions. Based upon the UTAUT/UTAUT2 description, the four building blocks are deployed in the HR department: talent acquisition, payroll processing, regulatory & Compliance management, and performance management, thus giving insights about recreating HRM services and enhancing the path of growth, improvement, and efficiency.

2.2. Blockchain application and its characteristics. In this section, we briefly describe the related work on the application of BCT in various industries and then summarize the possible advantages and disadvantages of BCT. Lastly, we explain in detail the utilization of BCT in Human Resource Management, followed by the identification of success factors.

2.2.1. Blockchain overview. Blockchain technology is one of the latest innovations across industries, practitioners, and academia. The subject accelerated enriching absorption post-2016 after the acceptance of cryptocurrencies as a non-fiat decentralized digital currency and payment infrastructure system that operate at a global level to prevent forgeries, false disputes, double spending etc [16]. Blockchain technology has versatile uses apart from recording financial transactions. This technology can be utilized for asset tracking and registration, decentralized voting and governance, healthcare information, transportation, digital supply chain and much more [17, 18]. Blockchain is explained as a decentralized, transactional database that stores a congruent, immutable, and chronological log of transactions between network participants [19, 20]. The record of validated information gets sealed by a cryptographic algorithm, linking blocks of data in form of a chain to ensure data integrity and standardized arrangement for the data access [21]. Each block contains the encrypted data and reference links to the preceding block hence maximizing the data preservation with a coded security system. Furthermore, all participants hold a copy of the ledger that cannot be altered retroactively, thus providing transparency, trustable and tamper-proof records [22]. Thus, the extensive literature show that the integration of blockchain technology with HRM practises could provide tremendous possibilities to deliver HR solutions at low expense associated with organization and development of sustainable smart cities. Table 2.1 and 2.2 highlights the benefits or essential blockchain technology enablers (BCTE's) that motivate organizations to incorporate blockchain in their HRM practices. However, there are a few challenges the organization initially face while the successful implementation of blockchain technology.

2.2.2. Impact of blockchain technology in HRM. Blockchain is cultivating momentous excitement in many aspects of industries by virtue of its design and architecture. Sivathanu [39]demonstrated that blockchain technology has great potential to upend HR functions that are not just restricted to talent management such as recruiting, developing and retaining new-age talent for achieving high performance at an organizational level. Blockchain will deeply impact HRM department roles and responsibilities, thus going to disrupt big picture areas like hiring, and payroll with its impressive services [40].The hiring process has become a daunting task for the human resource department of the organizations due to the false information provided by the job applicants on their CVs. Nearly,75% of hiring managers identified wrong credentials on the resume of applicants while applying for a suitable job [41]. Some job seekers hoax their academic degrees, employment letters, job titles and deliberately exaggerate their skills. The prime concern of the current organization is tracking down the potential candidate that could match the requirements of the vacant positions by witnessing their education, expertise and achievement [42].

The disruptive blockchain technology reduces the occurrence of unscrupulous entries and employers before hiring a candidate can get their most precise delineation and contestant's credentials. Thus, the integration of blockchain will verify the data submitted by the employee will provide genuine, transparent information, reduce costs and make it more effective [43]. Upon successfully verifying the candidate data, organizations can quickly release the offer letter, thereby saving significant time, effort and cost in the recruitment process. Concurrently, individuals can enhance their employability by voluntarily sharing their data with the recruiters as it improves employment opportunities and creates a culture of trust between the employee and the employers [44]. Moreover, recruiters can access the information about each candidate in real-time rather than receiving traditional resumes or viewing career networking websites like LinkedIn in near future. Thus, transforming the HRM function with a blockchain new intelligent hiring game plan.

Blockchain technology also emerged as a potential disruptor in the payment solutions arena. The greatest challenges faced by the HRM department in maintaining high volume financial operations. The procedure that employees value the most such as payroll process, taxes, cross-border transactions, and managing regulatory compliance can be made faster, secure and transparent with the advent of blockchain in the gig economy [45]. The application of blockchain in payments system ensures that participating parties can share sensitive information in a verified manner without relying on central authorities or third-party intermediaries, thus eliminating human errors and developing a trusted network [46].To sum up, HR managers would not be required to run a monthly payment or contact their company's bank, thus ensuring quick and low transmission costs for its customers or regulators. Instead, open real-time blockchain ledgers will help HRM head with invoice tracking as well as transaction distribution, invoicing, and reporting.

The next big space where blockchain can be used to automate the performance evaluation system. The performance management cycle is crucial for all employees in an organization because it is associated with the recognition, salary hike, training and career growth. With the introduction of online training courses, the availability of digital badges, and the vast array of courses, education, and academic achievements, HRM teams are finding it more difficult to maintain track of each employee's day-to-day activities in the organization [47]. Therefore, HR professionals are looking for new solutions to keep employees engaged and productive. The application can be developed to create a decentralized performance appraisal measurement system using

Table 2.1: Summary of benefits and limitations of blockchain adoption

Sr. No	Benefits/ BCT Enabler's	Description	Refs.	Challenges	Description	Refs.
1	Decentralized data records	In a decentralized network, data is not controlled by any large, centralized server but rather evenly distributed across different nodes (Peer to Peer Network).	[23]	Low Scalability	The blockchain scalability issue is connected to the fact that the size and frequency of records (or blocks) in the blockchain are restricted. The blockchain's blocks continue to expand in size as it is used, and each transaction takes longer to execute.	[32]
2	Consensus-based and Trustworthy Insights	All transactions are validated to concerned participants in real-time, thus ensuring the whole system is fault-tolerance.	[24]	Security enhancement	A 51% attack on the blockchain through node hacking may occur as a result of the lack of validator nodes. The entire data is vulnerable if one of the participant's private keys is lost or stolen. Hence, the system has no safety mechanism to provide additional security.	[33]
3	Immutability	The cryptographic hash algorithm ensures transaction data stored cannot be altered, corrupted, or removed thus, helps in maintaining a high level of robustness and trust.	[25]	High Energy Consumption	The consumption of power in the Blockchain is comparatively high due to mining activities. Every time the ledger is updated with a new transaction, the miners need to solve the problems which means excessive energy costs.	[34]
4	Transparency	Every user has identical copies of the ledger, to monitor and analyze the state of a transaction in its lifecycle, therefore, eliminating the information gap.	[26]	Regulatory and Legal Formalities	Due to the lack of laws and regulations governing blockchain and smart contracts, many organisations may not implement blockchain-based solutions.	[35]
5	Removal of non-value adding intermediary or cost reduction	BCT eliminate intermediaries or third parties hence maximizing transparency, cutting down the overall processing cost and offering a faster settlement of transactions.	[27]	Privacy Leakage	Blockchain is an open ledger that is accessible to all users to increase transparency and eliminate trust issues. But it becomes a liability if applied in a sensitive environment.	[36]

blockchain, smart contracts and crypto coins, thus providing a rewarding experience for an overall contribution of employees towards the organization over a given interval of time [48].

In the conventional centralized HRM transaction model, each transaction needs to be validated through

Table 2.2: Summary of benefits and limitations of blockchain adoption

Sr. No	Benefits/ BCT Enabler's	Description	Refs.	Challenges	Description	Refs.
6	Agile Information Sharing	The issues that hamper the HR process such as delays in payments, conflicts between parties, fraudulent practices and data vulnerability can be minimized with the help of blockchain. Thus, BCT facilitates sharing, exchanging and integration of information across all the network users.	[28]	Interoperability	Most blockchains operate on their own and do not interact with other peer networks as they cannot send and receive information from another blockchain-based system. It is one of the core reasons organizations are not adopting blockchain technology.	[37]
7	Secured database	The identities of users are kept anonymous throughout transactions to protect the security of data. The various functions such as deletion, updating etc. cannot be performed on electronic records, thus prevents from fraudulent actions.	[29]	Lack of Expertise Knowledge	Even though blockchain developers are in high demand, an extreme shortage of blockchain specialists and developers is a major concern for all organizations. The absence of trained and knowledgeable developers for managing and solving the complexity of peer-to-peer networks contributes to the slow rate of development.	[38]
8	Secured database	The identities of users are kept anonymous throughout transactions to protect the security of data. The various functions such as deletion, updating etc. cannot be performed on electronic records, thus prevents from fraudulent actions.	[30]			
9	Simplifies Audibility	It helps to control illicit activities, streamline audit processes, and improve financial reporting.	[31]			

the central trusted agency (e.g., the central bank or intermediaries), inevitably resulting in cost and performance bottlenecks at the central servers. However, a decentralized blockchain-based HRM system ensures a protection mechanism for sensitive information, with an automated verification credential process, building an interplanetary file system to track and store transactions safely without the involvement of third parties, thereby diminishing the usage of the traditional architecture approach [49] [50]. Thus, becomes crucial for the practitioners in the HRM to identify the drivers of the adoption of BCT and comprehend the co-relation among each other. Based on the above literature, a consolidated list of significant factors is framed and divided into Talent Acquisition, Payroll processing, Regulatory compliance procedures and Performance for the

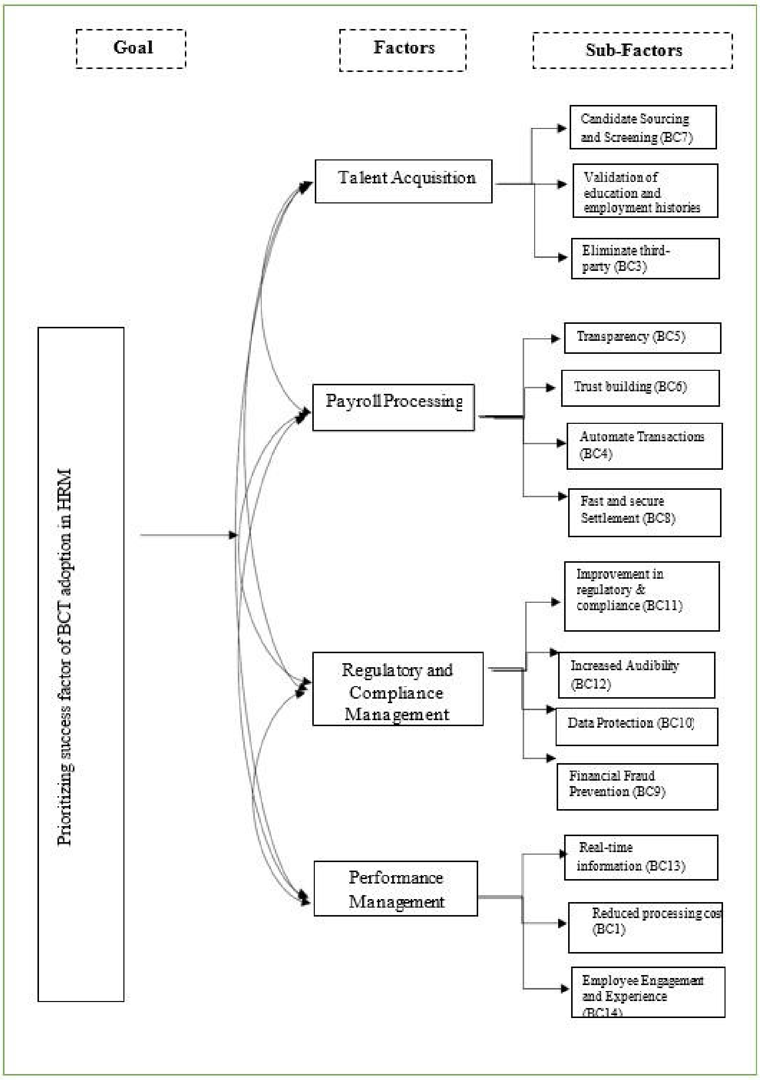

Fig. 2.1: AHP model for Blockchain Technology adoption in Human Resource Management

proposed model. This involves designing hierarchical levels and links between the chosen BCT enablers using a combination of the Fuzzy Analytic Hierarchy Process (F-AHP) and the Decision-Making Trial and Evaluation Laboratory (DEMATEL) methodology. Therefore, an attempt is being made to use various techniques and strategies that will encourage, engage, and create a high-performing management system that endorses the usage of blockchain technologies in the HRM sector at the workplace as depicted in Figure 2.1.

3. Proposed Methodology. Multi-criteria decision-making method [51] performs the analysis for determining the best criteria and structure to solve the complex multiple set problem.

The analytical hierarchal process (FAHP) is broadly used in various applications of multi-criteria decision analysis to discover solution of complicated issues [52]. However, AHP method have been impacted by certain flaws, such as judgements based on unbalanced scales, imprecision, uncertainty, and the biases of decision makers. To address this issues, fuzzy theory has been incorporated into the AHP, as supported by the relevant literature.The F-AHP approach arranges the factors and sub-factor according to their priority or rank. In addition, cause–effect correlations between factors are examined using modified-DEMATEL in this study. In

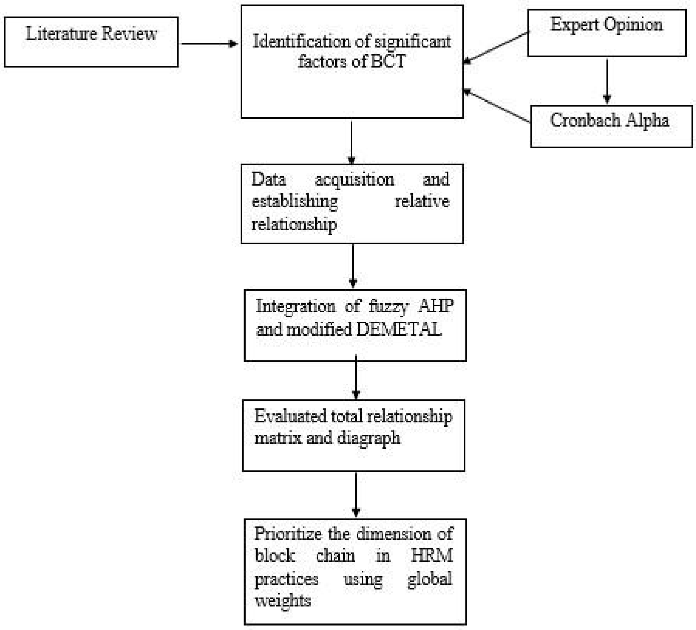

Fig. 3.1: Flow Process of Proposed Methodology

order to avoid uncertainties of human ideas and decisions in a dynamic environment, modified-DEMATEL has been preferred over standard DEMATEL.Therefore,modified-DEMATEL is applied to compute the significant factors and subfactors in order to analyze the inter-dependent relationship[53]. It provides the cause-and-effect mapping of critical significant factors on each other through digraph. The flow of the process has been depicted in Figure 3.1.

3.1. Cronbach Alpha. The critical significant factor has been identified from an extensive literature review and field survey. The survey was developed using a unique set of factors and subfactors from the existing literature and verified by the experts. In this paper, Cronbach Alpha has been used for assessing the strength of consensus agreement among the experts. A total of 15 HRM head/managers or consultants in the organization having deemed knowledge about the acquisition of blockchain in the HRM domain were approached to participate in the survey and were also assured of the confidentiality of their response if they consent to participate. The reliability or inner consistency of the designed questionnaire is determined with the help of Cronbach Alpha [54]. The test revealed a reliability score of 0.83, hence the survey questionnaire was found to be reliable.

3.2. Fuzzy AHP (F-AHP). Cheng et al.[55] presented the F-AHP technique enabling the extent analysis using a triangular fuzzy comparison matrix to determine a crisp priority vector. F-AHP technique is a more methodical approach than the other MCDM approaches to capture a human's perception of ambiguity when complicated multi-criteria decision-making situations are considered for the decision-making process. Due to this ability, F-AHP tends to be advantageous for strategizing and determining judgements to acquire more crisp information for accurate results. However, F-AHP is a more intricate method that requires numerical calculations in determining composite priorities than conventional AHP. In this study, the F-AHP method is employed to obtain the critical factor and subfactor weights to perform a comparison of the different judgement of expert's opinions [56]. Let object set and goal set be represented $Y = \{\ y1,\ y2.\ .\ .\ .\ .\ yn\}$ as and $Z = \{\ z1,$

$z2 \ldots .\ .\ zm\}$. The 'n' extent analysis values can be acquired using LJ ($j = 1, 2m$) depicting triangular fuzzy numbers.

The detailed step process is discussed as follows:

1. Determine the value of fuzzy synthetic weights with respect to the i_{th} object through Eq. 3.1

$$Q_i = \sum_{j-1}^{m} L_{z_i}^{j} \otimes \{\sum_{i-1}^{n}\sum_{j-1}^{n} L_{z_i}^{j}\}^{-1} \tag{3.1}$$

The fuzzy addition operation of 'n' extent analysis value is evaluated for a particular matrix as shown in Eq. 3.2. Further, the inverse of the vector is given by Eq. 3.3.

$$\sum_{j-1}^{m} L_{z_i}^{j} = \left(\sum_{j-1}^{m} r_j, \sum_{j-1}^{m} h_j, \sum_{j-1}^{m} h_j\right) \tag{3.2}$$

$$\left\{\sum_{i-1}^{n}\sum_{j-1}^{m} L_{z_i}^{j}\right\}^{-1} = \left(\frac{1}{\sum_{i-1}^{n}\sum_{j-1}^{m} r_j}, \frac{1}{\sum_{i-1}^{n}\sum_{j-1}^{m} h_j}, \frac{1}{\sum_{i-1}^{n}\sum_{j-1}^{m} h_j}\right) \tag{3.3}$$

2. Calculate the degree of possibility (DOG) between $Q1$ ($r1$, $h1$, $v1$) and $Q2$ ($r2$, $h2$, $v2$) fuzzy synthetic extent as defined in Eq. 3.1. The magnitude of likelihood between the two fuzzy synthetic extent is achieved through Eq. 3.4.

$$t(Q2 \geq Q1) = \sup g \geq y \exp \min(\mu q2(g), \mu q1(y))] \tag{3.4}$$

It can also be expressed using Eq. 3.5 and Eq 3.6 respectively.

$$t(Q2 \geq Q1) = hgt(Q1 \cap Q2) = \eta q2(k) \tag{3.5}$$

$$\eta_{q2}(k) = \begin{cases} 1 & \text{if } h2 \geq h1 \\ 0 & \text{if } r1 \geq r2 \\ \frac{r1-v2}{(h2-v2)-(h1-r1)} & \text{otherwise} \end{cases} \tag{3.6}$$

3. Measure the degree of possibility for convex fuzzy number is more than k, q_i ($i = 1, 2, ..., k$) can be depicted through Eq. 3.7.

$$t(q \geq q1, q2, ...qk) = t[(q \geq q1) \text{ and } (q \geq q2)... \text{ and } ...(q \geq qk)] = \min t(q \geq qi), i = 1, 2, 3...k \tag{3.7}$$

4. Determine normalized vector using Eq. 3.8. Assume that

$$b(B_i) = \min t(q \geq qi) NV = (d(B1), d(B2), ...d(Bk))^z \tag{3.8}$$

NV shows the non-fuzzy number computed for each comparison matrix.

3.3. Modified DEMATEL technique. Battelle Memorial Institute Geneva Research Centre proposed DEMETAL techniques for exploring and visualizing the modelling structure that emphasize the interdependent relationship with diagrams and matrices [57]. The detailed associated process of the M-DEMATEL method is described as follows:

1. Compute the average direct relation matrix D from the judgement of experts considering the impact of every factor on other factors. Assume that the study contains a set of factors as D and their mathematical relation e_{ij} ($i, j \in \{1, 2, 3.(m-1), m\}$ determined using pairwise comparison. So, e_{ij} shows the degree by which one factor or subfactors influence the other significant factor.

2. Normalization of direct relation matrix D such that the values can be acquired between 0 and 1 through Eq. 3.9 and 3.10 respectively.

$$O = K \cdot D \tag{3.9}$$

$$O = \min\left(\frac{1}{\max_{1\le i\le m}\sum_i = 1|a_{ij}|}.\frac{1}{\max_{1\le j\le m}\sum_j = 1|a_{ij}|}\right) \tag{3.10}$$

Here, $i, j \in \{1, 2, 3., (m-1), m\}$ where m shows the count of factors in this study.

3. Generate the normalized total direct relation matrix S (here S= identity matrix) depicted through Eq. 3.11.

$$S = M + M2 + M3 + M4 + ... = \sum_{M^i_{i=1}}^{\infty} M(1-M) - 1 \tag{3.11}$$

4. Determine dispatcher and receiver class using the value of the sum of rows (r) and the sum of column (c) as shown in Eq. 3.12 and Eq. 3.13. The critical factors acquiring the positive value of $(r-c)$ have higher influence and priority over other factors, therefore, referred to as dispatchers. However, negative values of $(r+c)$ have less influence on others, thus tend to get influenced from others, therefore, termed as a receiver. A higher value of $(r+c)$ shows the great degree of relationship among each factor.

$$S = (s_{i,j})_{m\times m}, \quad i, j \in \{1, 2, 3, ..., m-1, m\} \tag{3.12}$$

$$DP = \left(\sum_{j=1}^{n} s_{i,j}\right)_{n\times 1}, \quad RE = \left(\sum_{i=1}^{n} s_{i,j}\right)_{n\times 1} \tag{3.13}$$

5. Later, considering the factors that have a higher influence level than a certain threshold value in total relation matrix S are converted into a causality map referred to as impact digraphs.

$$\alpha = 1/m^2 \sum_{i=1}^{n}\sum_{j=1}^{n} s_{i,j} \tag{3.14}$$

The ranking of factors can be done on the basis of the absolute value of $r-c$ or the degree of relationship can be given through Eq. 3.15:

$$r(Bk) = \text{order } Bk(BP + C) \tag{3.15}$$

4. Experimental Result Analysis and Discussion. F-AHP method has been applied in various fields for solving complex decision problems. The structure of problems can be solved using numerous sub-factors using AHP, considering both qualitative and quantitative criteria in the same decision framework. The method is a multi-criteria technique based on selecting or ranking the best set of alternatives. Fuzzy AHP is a reliable tool for selecting significant factors, weight assignment to each identified factor and evaluation of alternative solutions in hierarchic matrices. To compute the relative weights, the fuzzy linguistic scale of importance has been considered as presented in Table 4.1. The opinions were collected by experts on the basis of their knowledge related to relevant factors and sub-factors to develop matrixes for pairwise comparison. The rating performed for each pair of factors important for embracing blockchain technology in human resource management practices is shown in Table 4.2. The AHP methodology consists of three principles: (i) Construction of hierarchical structure for the problem (ii) pair-wise comparative judgement on the basis of an expert's opinion that calculates the local weight (relative importance) on the identified criteria as shown in Table 4.3. (iii) synthesis of the local weight (relative importance) into global weights (Global importance) leading to the selection of the final decision as

Table 4.1: Fuzzy Linguistic Scale

Scale Importance	Fuzzy Scale	Fuzzy Scale Reciprocal
Equal	(1,1,1)	(1,1,1)
Moderate	(2,3,4)	(1/4,1/3,1/2)
Strong	(4,5,6)	(1/6,1/5,1/4)
Very Strong	(6,7,8)	(1/8,1/7,1/6)
Extremely Strong	(9,9,9)	(1/9,1/9,1/9)
Intermediate	(1,2,3) (3,4,5) (5,6,7) (7,8,9)	(1/3,1/2,1) (1/5,1/4,1/3) (1/7,1/6,2/5) (1/9,1/8,1/7)

Table 4.2: Factors value obtained from expert opinion

	Talent Acquisition	Payroll Processing	Compliance and Regulatory	Performance evaluation management
Talent Acquisition	1	9	4	4
Payroll Processing	0.111111	1	5	5
Compliance and Regulatory	0.25	0.2	1	7
Performance evaluation management	0.25	0.2	0.142857	1

Table 4.3: Factors value obtained from expert opinion

	Talent Acquisition	Payroll Processing	Compliance and Regulatory	Performance evaluation management
Talent Acquisition	1	9	4	4
Payroll Processing	0.111111	1	5	5
Compliance and Regulatory	0.25	0.2	1	7
Performance evaluation management	0.25	0.2	0.142857	1

Table 4.4: Fuzzy weights matrix for pair-wise comparison

Fuzzy AHP	Talent Acquisition	Payroll Processing	Compliance and Regulatory	Performance evaluation management		FUZZY Weights	
Talent Acquisition	1, 1, 1	9, 9, 9	3, 4, 5	3, 4, 5	0.45913	0.59572	0.76278
Payroll Processing	0.11,0.11,0.11	1, 1, 1	4, 5, 6	4, 5, 6	0.17671	0.22201	0.27853
Compliance and Regulatory	0.2, 0.25, 0.33	0.16,0.2,0.25	1,1,1	6,7,8	0.10233	0.13227	0.17796
Performance evaluation management	0.2, 0.25, 0.33	0.16, 0.2, 0.25	0.12, 0.14, 0.16	1, 1,1	0.03887	0.04999	0.06761

shown in Table 4.4. In spite of the distinct intellectual abilities of decision-makers, triangular fuzzy sets theory

Table 4.5: CTMC model parameters

Fuzzy AHP	Talent Acquisition	Payroll Processing	Compliance and Regulatory	Performance evaluation management	Normalized Values
Talent Acquisition	1, 1, 1	9, 9, 9	3, 4, 5	3, 4, 5	0.593232
Payroll Processing	0.11, 0.11, 0.11	1, 1, 1	4, 5, 6	4, 5, 6	0.221041
Compliance and Regulatory	0.2, 0.25, 0.33	0.16, 0.2, 0.25	1, 1, 1	6, 7, 8	0.134654
Performance evaluation management	0.2, 0.25, 0.33	0.16, 0.2, 0.25	0.12, 0.14, 0.16	1, 1, 1	0.051073

Table 4.6: Normalized fuzzy decision values

	B2	B3	B4	B5	B6	B6	B7	B8	B8	B9	B9
B2	0.020	0.137	0.176	0.098	0.098	0.098	0.059	0.078	0.078	0.078	0.078
B3	0.003	0.020	0.137	0.059	0.098	0.098	0.039	0.039	0.039	0.098	0.098
B4	0.002	0.002	0.020	0.098	0.137	0.137	0.059	0.039	0.039	0.039	0.039
B5	0.004	0.007	0.004	0.020	0.098	0.098	0.098	0.137	0.137	0.137	0.137
B6	0.004	0.004	0.003	0.004	0.020	0.020	0.020	0.039	0.039	0.039	0.039
B6	0.004	0.004	0.003	0.004	0.020	0.020	0.020	0.039	0.039	0.039	0.039
B7	0.007	0.010	0.007	0.004	0.020	0.020	0.020	0.059	0.059	0.078	0.078
B8	0.005	0.010	0.010	0.003	0.010	0.010	0.010	0.020	0.020	0.137	0.137
B8	0.005	0.010	0.010	0.003	0.010	0.010	0.007	0.020	0.020	0.137	0.137
B9	0.005	0.004	0.010	0.003	0.010	0.010	0.005	0.003	0.003	0.020	0.020
B9	0.005	0.004	0.010	0.003	0.010	0.010	0.005	0.003	0.003	0.020	0.020

Table 4.7: Normalized matrix of expert opinion

	B2	B3	B4	B5	B6	B6	B7	B8	B8	B9	B9	SUM
B2	0.027	0.152	0.215	0.137	0.174	0.174	0.105	0.140	0.140	0.191	0.191	1.645
B3	0.008	0.027	0.151	0.080	0.142	0.142	0.067	0.077	0.077	0.162	0.162	1.094
B4	0.006	0.008	0.028	0.107	0.165	0.165	0.082	0.077	0.077	0.101	0.101	0.916
B5	0.010	0.015	0.017	0.027	0.120	0.120	0.115	0.167	0.167	0.217	0.217	1.192
B6	0.006	0.007	0.007	0.007	0.026	0.026	0.024	0.047	0.047	0.061	0.061	0.317
B6	0.006	0.007	0.007	0.007	0.026	0.026	0.024	0.047	0.047	0.061	0.061	0.317
B7	0.009	0.014	0.014	0.009	0.030	0.030	0.026	0.069	0.069	0.110	0.110	0.490
B8	0.007	0.013	0.017	0.007	0.020	0.020	0.016	0.027	0.027	0.157	0.157	0.467
B8	0.007	0.013	0.017	0.007	0.019	0.019	0.012	0.027	0.027	0.157	0.157	0.462
B9	0.006	0.005	0.013	0.005	0.014	0.015	0.008	0.007	0.007	0.026	0.026	0.132
B9	0.006	0.005	0.013	0.005	0.014	0.015	0.008	0.007	0.007	0.026	0.026	0.132

is considered an appropriate technique to minimize uncertainty and biasness. The fuzzy AHP is preferential, due to its simplicity and higher consistency.

The proposed M-DEMATEL is a novel method that reflects the casual-effect relationship among the critical sub-factors by accommodating the perceptions of the respondents who are experts in the particular industry. The ranking obtained from fuzzy AHP shows that performance factors have been less significant as compared to other factors therefore, the normalized matrix considered for M-DEMATEL evaluation is shown in Table 4.5. Further, the normalized direct relationship matrix is computed as depicted in Table 4.6. The study presents the benefits of implementing blockchain in HRM activities calculated from the prominence score. The

Table 4.8: Normalized total direct relationship matrix

	B2	B3	B4	B5	B6	B6	B7	B8	B8	B9	B9
B2	0.016	0.092	0.131	0.083	0.106	0.106	0.064	0.085	0.085	0.116	0.116
B3	0.005	0.016	0.092	0.049	0.086	0.086	0.041	0.047	0.047	0.098	0.098
B4	0.004	0.005	0.017	0.065	0.100	0.100	0.050	0.047	0.047	0.061	0.061
B5	0.006	0.009	0.010	0.017	0.073	0.073	0.070	0.102	0.102	0.132	0.132
B6	0.003	0.004	0.004	0.004	0.016	0.016	0.015	0.028	0.028	0.037	0.037
B6	0.003	0.004	0.004	0.004	0.016	0.016	0.015	0.028	0.028	0.037	0.037
B7	0.005	0.009	0.009	0.005	0.018	0.018	0.016	0.042	0.042	0.067	0.067
B8	0.004	0.008	0.010	0.004	0.012	0.012	0.009	0.016	0.016	0.095	0.095
B8	0.004	0.008	0.010	0.004	0.012	0.012	0.007	0.016	0.016	0.095	0.095
B9	0.003	0.003	0.008	0.003	0.009	0.009	0.005	0.004	0.004	0.016	0.016
B9	0.003	0.003	0.008	0.003	0.009	0.009	0.005	0.004	0.004	0.016	0.016

Table 4.9: Representation of degree of influence

	B2	B3	B4	B5	B6	B6	B7	B8	B8	B9	B9	D	D+R	D-R
B2	0.016	0.092	0.131	0.083	0.106	0.106	0.064	0.085	0.085	0.116	0.116	1.000	1.058	0.942
B3	0.005	0.016	0.092	0.049	0.086	0.086	0.041	0.047	0.047	0.098	0.098	0.665	0.827	0.503
B4	0.004	0.005	0.017	0.065	0.100	0.100	0.050	0.047	0.047	0.061	0.061	0.556	0.860	0.253
B5	0.006	0.009	0.010	0.017	0.073	0.073	0.070	0.102	0.102	0.132	0.132	0.724	0.966	0.482
B6	0.003	0.004	0.004	0.004	0.016	0.016	0.015	0.028	0.028	0.037	0.037	0.193	0.648	-0.263
B6	0.003	0.004	0.004	0.004	0.016	0.016	0.015	0.028	0.028	0.037	0.037	0.193	0.648	-0.263
B7	0.005	0.009	0.009	0.005	0.018	0.018	0.016	0.042	0.042	0.067	0.067	0.298	0.594	0.002
B8	0.004	0.008	0.010	0.004	0.012	0.012	0.009	0.016	0.016	0.095	0.095	0.284	0.703	-0.136
B8	0.004	0.008	0.010	0.004	0.012	0.012	0.007	0.016	0.016	0.095	0.095	0.281	0.700	-0.139
B9	0.003	0.003	0.008	0.003	0.009	0.009	0.005	0.004	0.004	0.016	0.016	0.080	0.851	-0.690
B9	0.003	0.003	0.008	0.003	0.009	0.009	0.005	0.004	0.004	0.016	0.016	0.080	0.851	-0.690
R	0.058	0.162	0.303	0.242	0.456	0.456	0.296	0.419	0.419	0.770	0.770			

normalized total direct relationship matrix is evaluated and represented in Table 4.7. The normalized total relation matrix is computed by summing the direct effects and all the indirect effects. A better understanding of interrelationships can be obtained by thoroughly analyzing the total relation matrix as represented by S in equation 12.

D+R can be known as the degree of the central role that illustrates the strength that are given (Dispatched) and received (Receiver) of the factor. Similarly, the vertical axis vector (D-R) called "Relation" shows the net effect that the factor contributes to the system. If (D-R) is positive, then the factor can be categorized into cause groups; if (D+R) is negative, then the factor can be clustered into the effect group. Certainly, a Casual diagram can be generated by plotting the set of data (D+R, D-R), showing the reasonable observation for strategic decision making as shown in Table 4.8.

5. Managerial implication. The study finding has significant managerial implications and insights that will enable multinational companies to integrate blockchain into HRM functions. According to the literature review strategy, the applications of blockchain technology are eventually gaining alignment with the HRM sector. Therefore, this paper facilitates the organizational decision-makers, HR practitioners expert IT managers as well as industry 4.0 developers to capture all appropriate information about how blockchain and HRM systems may work together to benefit both the company and the employees. The blockchain-based human resource recruitment system (BcHRS) will digitally verify official credentials and resumes to ease the HR professional's recruitment process in identifying the right candidate for an open position. The hiring process will undoubtedly transform with the added benefits of blockchain in terms of efficiency, quality, and low costs. Similarly, a global blockchain payroll solution can simply provide a speedier solution than current approaches. As a result of blockchain in payroll management, HR professionals or managers handling employee payroll, tax compliances, medical information, and vacation may find it easier to control cross-border expenses. Moreover, our findings include that blockchain technology offers a higher level of security than many existing technologies and also blockchain might also be utilized for employee learning records or other information stored in HRM systems. HR has the chance to improve workplace environments in accordance with corporate needs and increasing employee expectations. Blockchain is one of the technologies in which HRM should invest as part of its technological innovation in the HRM system.

6. Conclusion and Future Scope. Industry 4.0 is a paradigm that is transforming the way organizations operate by utilizing cutting-edge technology. The study was conducted to identify the critical success factors that encourage blockchain adoption in HRM and to establish the causal relationship among various sub-factors. The exploration to determine the significant factors as well subfactors of BCT adoption and its framework using a combined F-AHP and M-DEMATEL method is derived. The application of technology enabled solution in Industry 4.0 is estimated to rise and benefit a wide range of sectors. The result analysis indicates that the use of advance technology enhances and optimizes various HRM sectors to thrive in the digitization era for IOT smart cities.

In future, a blockchain-based intelligent HRM portal might give each employee as well as manager a single, targeted, and frequently customized access point. Employee self-service interaction system (ESS) and HR manager self-service system (MSS) are the two basic components and prerequisites for capturing those prospective applications. These two essential themes will be crucial in building blockchain-based smart HRM corporations. Further, analysis can be conducted for addressing the barriers and different dimensions of HRM to overcome the shortcomings while the adoption of intelligent solution.

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