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A Fuzzy TOPSIS Method for Assessment Blockchain Technology Strategies

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Abstract: Assessing blockchain technology strategies is crucial for organizations seeking to leverage the potential benefits of blockchain in their operations. We explore the importance of evaluating blockchain technology strategies and emphasize critical considerations in the assessment process. These considerations encompass aligning strategy with business objectives, evaluating technology capabilities, analyzing implementation challenges, assessing security and privacy implications, considering regulatory compliance, and measuring the impact of the strategy. The study outlines the significance of a comprehensive assessment in ensuring the effectiveness and success of blockchain technology strategies. By conducting thorough assessments, organizations can make informed decisions, mitigate risks, and maximize the value of implementing blockchain technology. This study proposed utilizing the fuzzy set to handle and evaluate the linguistic data. We integrated the fuzzy set with the TOPSIS method to show the rank of strategies. We collect ten criteria and ten strategies in this study. We conducted a sensitivity analysis to show the stability of the results.

Keywords: TOPSIS Method; MCDM, Blockchain; Fuzzy Sets; Assessment Problem.

1. Introduction

Blockchain technology has emerged as a transformative force, revolutionizing various industries and redefining how we transact, interact, and establish trust in the digital age. Originally introduced as the underlying technology for the cryptocurrency Bitcoin, blockchain has since evolved into a powerful and versatile technology with applications reaching far beyond digital currencies. At its core, blockchain is a decentralized and distributed ledger that records transactions or data across multiple computers, known as nodes, in a transparent and immutable manner. Each transaction or data entry, known as a block, is linked to the previous block, forming a chain of blocks. This decentralized nature ensures that no single entity has control or ownership over the entire blockchain, making it resistant to tampering, fraud, and censorship[1]–[3].

The critical innovation of blockchain lies in its ability to establish trust and enable secure transactions without intermediaries such as banks, governments, or third-party intermediaries. By leveraging cryptographic algorithms, consensus mechanisms, and decentralized validation, blockchain provides a transparent and verifiable record of transactions, eliminating the need for trust to be placed solely in a centralized authority. Blockchain technology has transformative implications across a wide range of industries. In finance, it enables faster and more secure cross-border transactions, improves supply chain management transparency, enhances healthcare record-keeping efficiency, facilitates provenance tracking in the food and beverage industry, and enables decentralized applications with smart contracts[4]–[6].

The benefits of blockchain technology are numerous. It enhances transparency, as all participants in the network can access the same information, reducing the potential for fraud and disputes. Immutability ensures that once a transaction is recorded on the blockchain, it cannot be altered or deleted, providing high data integrity[7], [8]s. The decentralized nature of blockchain eliminates the need for intermediaries, reducing costs and increasing efficiency. However, blockchain technology has challenges. Scalability, energy consumption, regulatory frameworks, interoperability, and privacy concerns are among the issues that must be addressed for widespread adoption. As the technology continues to mature, efforts are being made to develop solutions that address these challenges and unlock the full potential of blockchain in various industries. Blockchain technology has emerged as a revolutionary innovation with the potential to transform industries by providing decentralized, transparent, and secure solutions. Its ability to establish trust, enhance efficiency, and enable new business models has captured the attention of businesses, governments, and technologists worldwide. As technology continues to evolve, it is expected to drive innovation, reshape industries, and create new opportunities for collaboration and value creation in the digital era[9], [10], [10].

A key area in system theory and management research is fuzzy multi-criteria decision-making (FMCDM), which has several decision criteria and choices[11], [12]. Based on the chosen criteria, MCDM seeks to determine which alternative or alternatives from a group of options are the most suitable. Numerous issues in engineering, finance, leadership, and society may be resolved using MCDM methodologies[13]–[15].

The frequently utilized mathematical technique is TOPSIS. Its central concept is to measure each alternative's distance to positive (PIS) and negative ideal solutions (NIS) to choose the best option[16], [17], [17]. In contrast to NIS, the least desired option for maximizing cost requirements and reducing profit requirements, PIS is an alternative and the solution that decision-makers (DMs) prefer. The choice furthest from the NIS and nearest to the PIS is then used to create the desired order, creating a scalar criterion that incorporates the two distance measurements with the best option[18]–[20].

2. Materials and Methodology

We collect the criteria related to the blockchain technology strategy. We collect ten criteria and ten strategies to select the best one[21]–[24]. The following are the criteria of this study.

I. Clear Business Objectives: Clearly define the blockchain technology strategy's business objectives. This may include enhancing transparency, improving efficiency, reducing costs, enabling new business models, or enhancing security. Align the strategy with these objectives to ensure a focused and meaningful approach.

II. Use Case Identification: Identify specific use cases where blockchain technology can provide value. Evaluate areas where trust, immutability, decentralized control, and transparency are crucial. Focus on use cases that can benefit from blockchain's unique features and capabilities, such as supply chain management, healthcare records, financial transactions, or intellectual property rights management.

III. Technology Assessment: Evaluate different blockchain technologies and platforms available in the market. Consider scalability, security, interoperability, consensus mechanisms, and development tools. Choose a technology that best suits the requirements of the identified use cases and aligns with the organization's technological capabilities.

IV. Governance and Legal Considerations: Establish precise blockchain network or ecosystem governance mechanisms. Define roles, responsibilities, and decision-making processes. Consider legal and regulatory aspects, such as data privacy, compliance with industry-specific regulations, and intellectual property rights. Ensure that the strategy adheres to relevant laws and regulations.

V. Integration with Existing Systems: Assess the integration requirements with existing systems and infrastructure. Determine how the blockchain solution will interact with legacy systems, databases, and external interfaces. Plan for smooth integration to avoid disruptions and maximize the benefits of blockchain technology.

VI. Security and Privacy: Consider the security and privacy implications of implementing a blockchain solution. Evaluate encryption, access controls, identity management, and data anonymization mechanisms. Ensure that sensitive data is protected and that the blockchain network resists attacks and unauthorized access.

VII. Scalability and Performance: Evaluate the scalability and performance requirements of the blockchain solution. Consider factors such as transaction throughput, network capacity, and latency. Choose a blockchain architecture and consensus mechanism to handle the anticipated workload and provide the necessary performance levels.

VIII. Collaboration and Ecosystem Building: Assess opportunities for cooperation with other organizations, industry consortia, or technology providers. Identify potential partners or stakeholders who can contribute to the success of the blockchain initiative. Foster an ecosystem that encourages participation, innovation, and interoperability.

IX. User Experience: Consider the user experience and ensure the blockchain solution is intuitive, user-friendly, and accessible. Design interfaces and applications that make it easy for users to interact with the blockchain system without requiring deep technical knowledge.

X. Continuous Evaluation and Adaptation: Establish mechanisms for constantly evaluating and improving the blockchain strategy. Monitor key performance indicators and metrics to assess the impact and effectiveness of the blockchain solution. Adapt the strategy to address emerging challenges, technological advancements, and changing business requirements.

We collect ten strategies of blockchain technology [25]–[28]as:

1. Proof of Concept (PoC) Development: Organizations may start by conducting proof-of-concept projects to explore blockchain technology's feasibility and potential benefits. This strategy involves developing small-scale prototypes or pilots to test specific use cases, validate assumptions, and gather insights before committing to larger-scale implementations.

2. Supply Chain Optimization: Blockchain can enhance supply chain management by providing transparency, traceability, and immutability of transactions and data. Organizations may develop strategies to implement blockchain-based solutions for tracking and verifying the movement of goods, reducing fraud, improving inventory management, and streamlining logistics processes.

3. Decentralized Applications (DApps): Organizations may focus on developing decentralized applications (DApps) that leverage blockchain's decentralized nature. DApps can provide new business models, improve efficiency, and enhance user experiences by eliminating intermediaries, enabling peer-to-peer transactions, and ensuring data integrity.

4. Smart Contracts Implementation: Smart contracts are self-executing contracts with predefined rules written on the blockchain. Organizations can develop strategies to leverage smart contracts for automating processes, reducing paperwork, ensuring compliance, and improving contract management efficiency.

5. Tokenization and Asset Management: Blockchain enables tokenizing physical and digital assets, allowing fractional ownership and efficient transfer of value. Organizations may develop strategies to tokenize real estate, intellectual property, or financial instruments, enabling new investment opportunities and streamlining asset management.

6. Identity Management and Authentication: Blockchain can provide a secure and decentralized system for managing digital identities and authentication. Organizations may develop strategies to leverage blockchain for identity verification, reducing identity theft, improving privacy, and enhancing user control over personal data.

7. Financial Services Innovation: Blockchain technology has significant implications for the financial industry, enabling faster and more secure transactions, reducing costs, and enhancing transparency. Strategies in this area may focus on implementing blockchain-based payment systems, cross-border remittances, peer-to-peer lending platforms, or trade finance solutions.

8. Data Security and Privacy: Blockchain's decentralized and immutable nature can enhance data security and privacy. Organizations may develop strategies to leverage blockchain for secure data storage, encrypted communications, and audit trails, ensuring data integrity and protection against unauthorized access.

9. Collaborative Networks and Consortia: To leverage the benefits of blockchain technology, organizations may form collaborations and consortia with industry peers, competitors, and technology providers. These strategies aim to establish blockchain-based networks or ecosystems, enabling shared infrastructure, interoperability, and collaborative innovation.

10. Regulatory Compliance and Governance: Blockchain strategies should consider compliance with relevant regulations and establish appropriate governance frameworks. Organizations may develop strategies to ensure compliance with data.

The fuzzy method is integrated with the fuzzy method and the criteria and alternatives are evaluated by the linguistic terms of the fuzzy sets[29], [30]. Figure 1 shows the steps of the fuzzy TOPSIS method.

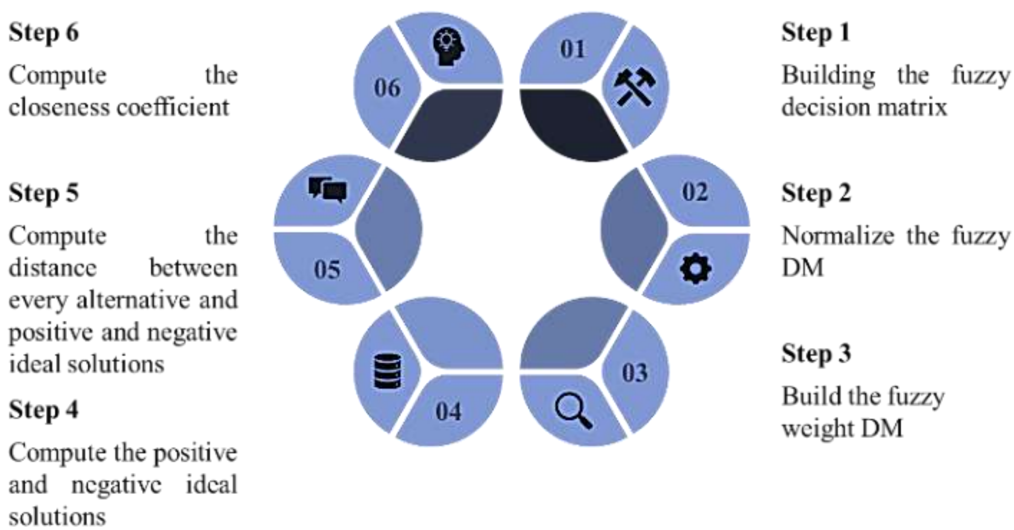

Figure 1. The steps of the fuzzy TOPSIS method.

2.1 Building the fuzzy decision matrix (DM).

$$F = \begin{bmatrix} f_{11} & \cdots & f_{1n} \\ \vdots & \ddots & \vdots \\ f_{m1} & \cdots & f_{mn} \end{bmatrix} \quad (1)$$

Where $f_{ij} = (a_{ij}, b_{ij}, c_{ij}); i = 1,2,, \dots m; j = 1,2, \dots n$

2.2 Normalize the fuzzy DM

$$y_{ij} = \left\{ \frac{a_{ij}}{c_j^+}, \frac{b_{ij}}{c_j^+}, \frac{c_{ij}}{c_j^+} \right\} \quad (2)$$

Where c_j^+ refers to the maximum value.

2.3 Build the fuzzy weight DM.

$$t_{ij} = y_{ij} \times w_j \quad (3)$$

2.4 Compute the positive and negative ideal solutions.

$U^+ = \{t_1^+, t_2^+, \dots t_n^+\} = \{\max t_{ij}\}$ (4)

$U^- = \{t_1^-, t_2^-, \dots t_n^-\} = \{\min t_{ij}\}$ (5)

2.5 Compute the distance between every alternative and positive and negative ideal solutions.

$o_i^+ = \sum_{j=1}^{n} o\left(t_{ij} - t_j^+\right)$ (6)

$o_i^+ = \sum_{j=1}^{n} o\left(t_{ij} - t_j^-\right)$ (7)

2.6 Compute the closeness coefficient

$C_i = \frac{o^-}{o^- + o^+}$ (8)

3. Results and Discussion

We conducted the fuzzy TOPSIS method for the assessment of the strategies on blockchain technology. We gathered ten criteria and ten alternatives.

3.1 Building the fuzzy decision matrix (DM) by Eq. (1)

3.2 Normalize the fuzzy DM by Eqs. (2) as shown in Table 1.

3.3 Build the fuzzy weight DM by Eq. (3) as shown in Table 2.

Table 1. The normalization DM.

	BDC$_1$	BDC$_2$	BDC$_3$	BDC$_4$	BDC$_5$	BDC$_6$	BDC$_7$	BDC$_8$	BDC$_9$	BDC$_{10}$
BDA$_1$	0.050189	0.101797	0.145693	0.266123	0.365148	0.391675	0.395033	0.189405	0.246034	0.274721
BDA$_2$	0.150566	0.254493	0.437079	0.319348	0.365148	0.304636	0.225733	0.426162	0.295241	0.228934
BDA$_3$	0.301131	0.305392	0.437079	0.266123	0.273861	0.217597	0.225733	0.33146	0.246034	0.366295
BDA$_4$	0.100377	0.458088	0.33995	0.266123	0.273861	0.391675	0.282166	0.426162	0.098414	0.320508
BDA$_5$	0.250943	0.254493	0.388514	0.266123	0.228218	0.391675	0.282166	0.284108	0.295241	0.412082
BDA$_6$	0.401508	0.407189	0.437079	0.425797	0.091287	0.130558	0.1693	0.142054	0.442861	0.366295
BDA$_7$	0.451697	0.305392	0.242821	0.372572	0.365148	0.391675	0.3386	0.236757	0.393654	0.228934
BDA$_8$	0.35132	0.152696	0.145693	0.319348	0.410792	0.304636	0.451466	0.426162	0.246034	0.274721
BDA$_9$	0.401508	0.254493	0.194257	0.425797	0.410792	0.261116	0.282166	0.094703	0.295241	0.412082
BDA$_{10}$	0.401508	0.458088	0.145693	0.106449	0.228218	0.261116	0.395033	0.378811	0.442861	0.183147

Compute the weights of criteria by the average method as shown in Figure 2. The business objectives criterion is the best criterion.

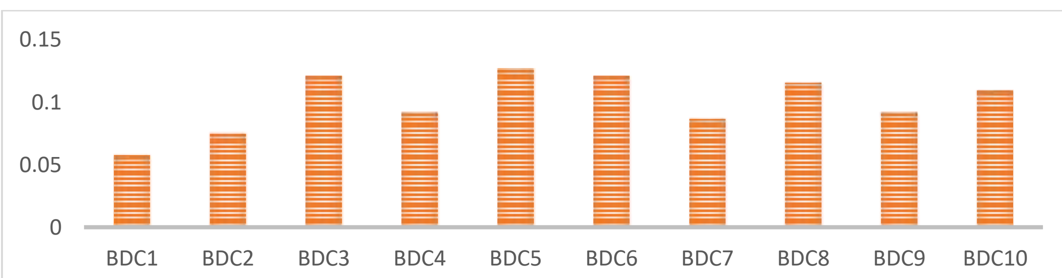

Figure 2. The weights of blockchain technology strategies.

Table 2. The fuzzy weight DM.

	BDC1	BDC2	BDC3	BDC4	BDC5	BDC6	BDC7	BDC8	BDC9	BDC10
BDA1	0.002901	0.00765	0.017685	0.024613	0.046435	0.047544	0.034251	0.021897	0.022755	0.030172
BDA2	0.008703	0.019124	0.053056	0.029535	0.046435	0.036979	0.019572	0.049267	0.027305	0.025143
BDA3	0.017406	0.022949	0.053056	0.024613	0.034826	0.026414	0.019572	0.038319	0.022755	0.040229
BDA4	0.005802	0.034423	0.041266	0.024613	0.034826	0.047544	0.024465	0.049267	0.009102	0.0352
BDA5	0.014505	0.019124	0.047161	0.024613	0.029022	0.047544	0.024465	0.032845	0.027305	0.045258
BDA6	0.023209	0.030598	0.053056	0.03938	0.011609	0.015848	0.014679	0.016422	0.040958	0.040229
BDA7	0.02611	0.022949	0.029475	0.034458	0.046435	0.047544	0.029358	0.027371	0.036407	0.025143
BDA8	0.020308	0.011474	0.017685	0.029535	0.052239	0.036979	0.039144	0.049267	0.022755	0.030172
BDA9	0.023209	0.019124	0.02358	0.03938	0.052239	0.031696	0.024465	0.010948	0.027305	0.045258
BDA10	0.023209	0.034423	0.017685	0.009845	0.029022	0.031696	0.034251	0.043793	0.040958	0.020114

3.4 Compute the positive and negative ideal solutions by Eqs. (4 and 5)

3.5 Compute the distance between every alternative and positive and negative ideal solutions by Eqs. (6 and 7).

3.6 Compute the closeness coefficient as shown in Figure 3 by Eq. (8). Alternative 2 is the best and alternative 1 is the worst.

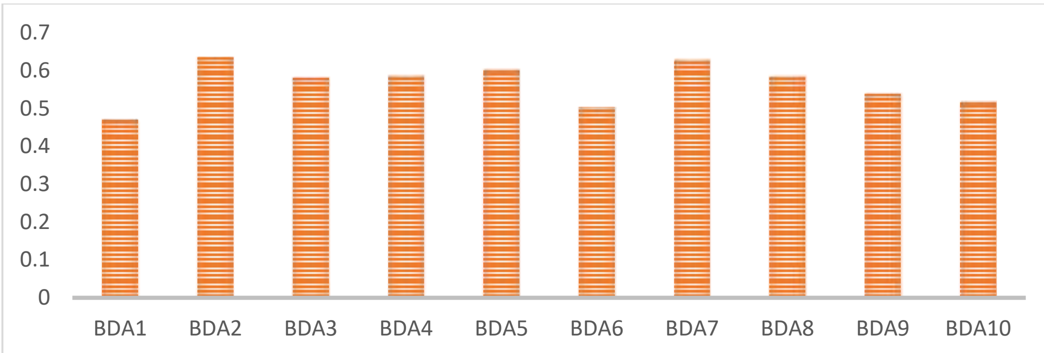

Figure 3. The rank of strategies in blockchain technology.

4. Analysis

We change the criteria weights by the ten cases to show the rank of alternatives. We put one criterion with 0.12 weight; all other criteria have equal weights, as shown in Figure 4. Then, we used these cases in the fuzzy TOPSIS method. We offer the rank of alternatives, which is stable, as shown in Figure 5.

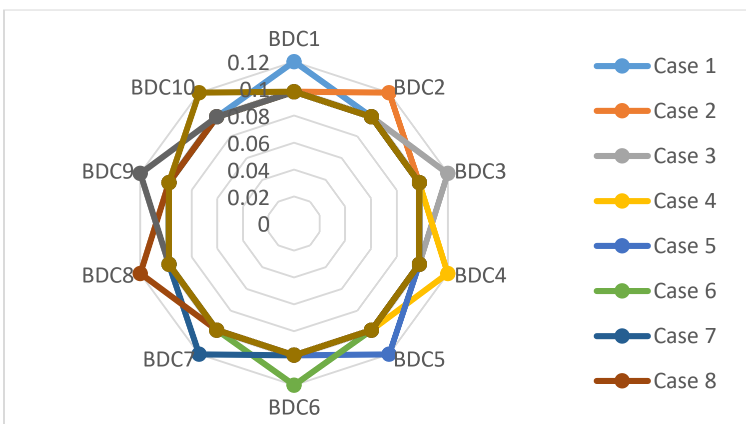

Figure 4. The ten cases in weights of blockchain technology strategies.

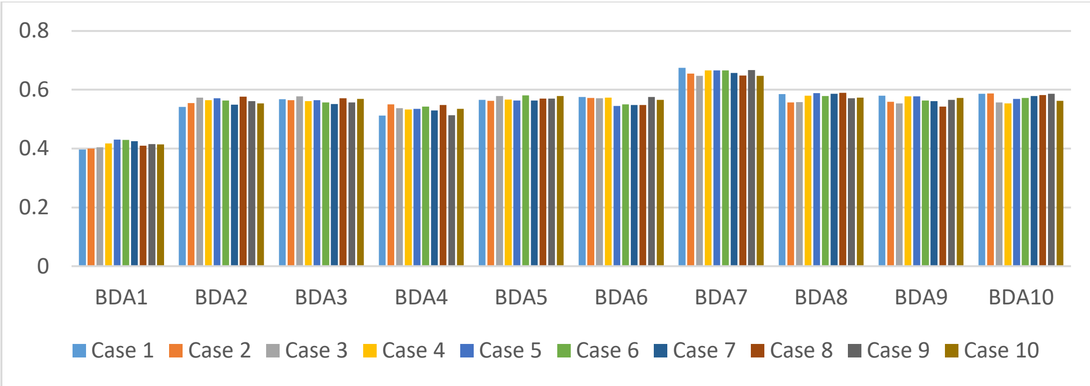

Figure 5. The rank of strategies under different cases.

5. Conclusions

Assessing blockchain technology strategies is a critical step in adopting and implementing blockchain solutions. The evaluation process enables organizations to align strategy with business objectives, identify potential challenges, and optimize the benefits of blockchain technology. By conducting comprehensive assessments of blockchain technology strategies, organizations can make well-informed decisions, mitigate risks, and maximize the benefits of blockchain implementations. The assessment process ensures that strategies are aligned with business objectives, technology capabilities, security and privacy requirements, regulatory compliance, and measurable impact. Through careful evaluation and continuous improvement, organizations can maximize the potential of blockchain technology and drive innovation in their respective industries. We used the fuzzy set in this study to deal with the vague data. The fuzzy set is integrated with the TOPSIS method to show the rank of strategies. We offer the strategy 2 is the best and strategy 1 is the worst. We conducted the sensitivity analysis to show the stability of the results.

Author Contributions

All authors contributed equally to this work.

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Ethical approval

This article does not contain any studies with human participants or animals performed by any of the authors.

Conflicts of Interest

The authors declare that there is no conflict of interest in the research.

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