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Research on the Selection of Audit Blockchain Service Providers Based on Analytic Hierarchy Process

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Abstract: Blockchain has been concerned by all walks of life since it was proposed, including the audit industry, because of its decentralized, open and transparent, secure encryption, traceability and other characteristics. At the present stage, the on-site audit is the main method, supplemented by network audit, which has the disadvantages of high cost, tedious basic work, low audit efficiency, time lag, high risk, easy tampering of electronic data, and low security. The integrated development of blockchain and audit can improve audit efficiency, reduce audit risk and improve audit timeliness. The blockchain distributed data storage and storage methods also have a significant impact on internal audit. Based on the analytic hierarchy process, this paper provides index selection and calculation examples for enterprises in the selection of audit blockchain service providers, and provide referential suggestions for enterprises in the selection of audit blockchain service providers.

1 Introduction

1.1 Research Background and Significance

Blockchain technology offers transformative solutions to challenges in traditional auditing, which faces inefficiencies, high costs, and security risks. Conventional methods rely heavily on on-site reviews and ERP systems, constrained by data vulnerability and delayed verification. Blockchain's decentralized architecture ensures tamper-proof data storage through distributed synchronization and cryptographic validation, enhancing transparency and eliminating third-party dependencies. Integrating blockchain into auditing preserves core audit objectives while innovating workflows[1-2]. By accessing immutable, real-time financial data from a trusted decentralized network, auditors reduce verification efforts and costs. This "Blockchain + Auditing" model improves data reliability, cuts risks, and accelerates processes without altering audit principles[3-4]. To adopt this technology, enterprises must evaluate blockchain audit service providers effectively. The Analytic Hierarchy Process (AHP) provides a structured decision-making framework, enabling businesses to balance technical capabilities and operational needs for optimal provider selection[5]. This approach supports efficient adoption of blockchain-augmented auditing, aligning with modern demands for secure, agile financial oversight.

2. The application of blockchain technology in auditing

2.1 Blockchain Technology

Blockchain technology offers solutions to traditional auditing challenges through its decentralized, cryptographic foundation. As a distributed shared database, blockchain eliminates reliance on centralized institutions by establishing trust via mathematical principles and peer-to-peer networks. Its decentralized structure ensures data authenticity and low-cost information transmission, fostering open, transparent, and verifiable systems. Blockchain functions as a shared ledger for collective accounting, where transactions are recorded across interconnected nodes. This distributed architecture removes dependency on central hardware, enabling synchronized verification and backup of transactions by all network nodes. Data security and reliability are enhanced through tamper-resistant synchronization across the entire network, with transparency for non-private information. Blockchain autonomously ensures trust without third-party intermediaries, creating a secure, self-regulated environment for data integrity.

2.2 Problems in Traditional Audit Work

Auditing is of great significance for the important operation of an economy. Efficient auditing examines the financial status of a company while maximizing resource savings, providing support for its operations. At present, traditional auditing work in China mainly relies on on-site auditing, supplemented by online auditing, which has certain drawbacks.

2.2.1 On site Audit

(1) The audit cost is high and the basic work is tedious. On site auditing requires auditors to personally visit the audited entity. In most cases, the accounting firm and the audited entity are not in the same area, and when they are far apart, it will result in higher travel expenses. On the other hand, auditors also need to spend a certain amount of manpower and material resources to verify the authenticity of relevant financial information through auditing procedures, which generally leads to higher audit costs.

(2) Low audit efficiency. In traditional audit work, the financial information provided by the audited party may not be true and accurate, and auditors need to spend time verifying the authenticity of the financial information. Specific audit procedures generally include inspection, observation, inquiry, letter confirmation, recalculation, re execution, and analysis procedures. When the financial data of the audited entity is large in scale, more time is spent on verifying the authenticity of the data, so the audit efficiency is relatively low under the traditional audit operation mode

(3) The audit time lags behind and the audit risk is high. Firstly, traditional post audit involves auditing the transactions that have occurred in the past period of time of the audited entity. The time difference between the occurrence of the transactions and the audit by the auditors increases the possibility of the audited entity tampering with financial information and also increases the risk of financial fraud. Secondly, in the case where the authenticity of the company's financial data is uncertain, auditors need to provide letters of confirmation to third parties such as banks, customs, tax bureaus, and customers. However, the letter of confirmation process is cumbersome, the response rate is limited, and auditors cannot verify all transaction items one by one, so the audit risk is also relatively high.

2.2.2 Network Audit

(1) Electronic data is prone to tampering. On site audit inspections usually focus on paper materials, and tampering with paper materials can leave traces and easily attract the attention of auditors. Therefore, audited units generally rarely make changes to paper materials. But online auditing is different from on-site auditing. The object of online auditing is electronic financial data, which is easily tampered with by the audited unit without any trace. After tampering, it is difficult for auditors to detect, which increases the difficulty of auditors distinguishing the authenticity of financial information and increases audit risks.

(2) Low data security. In online auditing, the vast majority of financial information of the audited entity is stored in the company's database. Financial data is the core data of a company. Once the company's database system is invaded illegally and financial data is leaked, it can easily have a negative impact on the company's development.

2.3 Innovation of blockchain in auditing

The application of blockchain technology in the field of auditing has not changed the essence or content of auditing work, but has innovated the working mode of auditing.

(1) Reduce data validation costs, improve audit efficiency, and lower audit risks

One of the biggest differences between "blockchain+auditing" and traditional auditing is the different data source channels. Based on the characteristics of immutability, autonomy, decentralization, and transparency of blockchain, auditors can obtain data within the trusted environment from blockchain. Trusting the authenticity and reliability of data within the environment can reduce the cost of data verification for auditors. Compared to traditional auditing, the amount of data that auditors need to verify authenticity has been reduced, and the authenticity of data has also been improved. Therefore, it can reduce audit costs and risks, and improve audit efficiency.

(2) Improve audit timeliness

In traditional auditing, there may be discrepancies between the bank deposit journal balance and the bank statement balance. For example, when a bank transfers funds from a company's deposit account to pay for the company's utilities, the bank deposit balance decreases. However, before the bank statement is sent to the enterprise, the bank deposit journal balance of the enterprise does not decrease, resulting in differences that reflect the lag of traditional financial information. In blockchain, every node has an equal status. When a node generates data due to economic activities, other nodes will synchronously copy and store the data. Therefore, auditors can query real-time data on public interfaces, improving the timeliness of audits.

(3) Accelerate the realization of intelligent audit work

Blockchain has the characteristic of being programmable. With the integration of blockchain and audit services, auditors in the future can write corresponding audit algorithms and rules according to audit needs, accelerate the intelligence of audit work, and improve audit efficiency.

Based on the above three advantages, "blockchain+audit" is an innovation in the audit work mode, which is based on blockchain technology. Auditors can comprehensively utilize blockchain application systems and the blockchain data of the audited company, and use data analysis technology to carry out audit work, which helps to improve audit efficiency and reduce audit risks.

3. Analytic Hierarchy Process

3.1 Introduction to Analytic Hierarchy Process

Analytic Hierarchy Process (AHP) refers to a systematic approach that decomposes a complex multi-objective decision-making problem into multiple objectives or criteria, and further decomposes them into several levels of multiple indicators (or criteria, constraints). By using qualitative indicators and fuzzy quantification methods, the hierarchical single ranking (weight) and total ranking are calculated to optimize decision-making for multiple objectives (multiple indicators) and multiple schemes.

The Analytic Hierarchy Process (AHP) decomposes a decision-making problem into different hierarchical structures in the order of the overall objective, sub objectives at each level, evaluation criteria, and specific contingency plans. Then, by solving the eigenvectors of the judgment matrix, the priority weights of each element at each level relative to a certain element at the previous level are obtained. Finally, the weighted sum method is used to hierarchically merge the final weights of each alternative plan relative to the overall objective. The one with the highest final weight is the optimal plan.

The Analytic Hierarchy Process is more suitable for decision-making problems with hierarchical and staggered evaluation indicators for target systems, and the target values are difficult to quantitatively describe.

3.2 Steps of Analytic Hierarchy Process

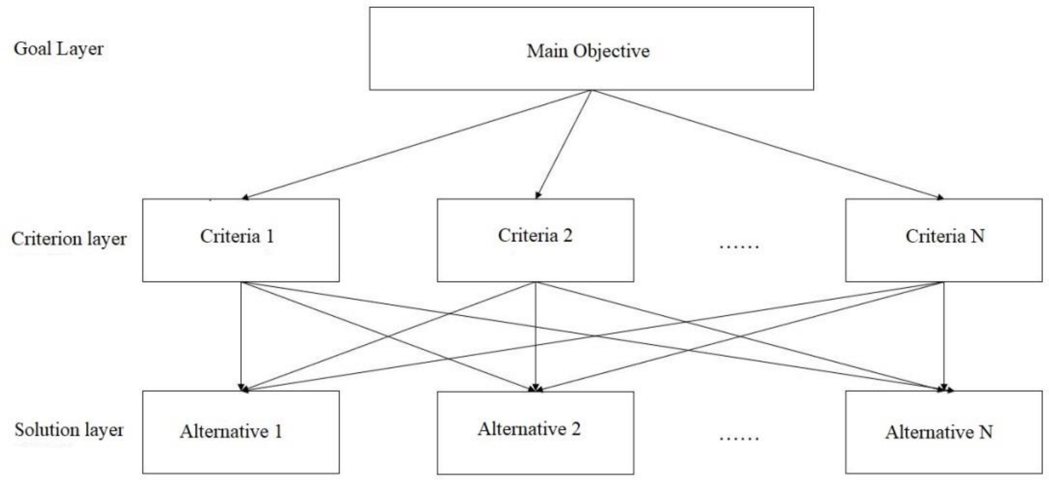

Figure 1. Hierarchical Structure Model

(1) Establish a structural hierarchy model

The Analytic Hierarchy Process decomposes the main objective into multiple criteria, with multiple alternative solutions under each criterion, constructing a hierarchical structure model of the structural hierarchy model of the Goal Layer - criterion layer - Alternative Layer, as shown in the figure 1.

(2) Establish a pairwise comparison matrix

Based on the structural hierarchy model, the Analytic Hierarchy Process invites experts to compare pairwise criteria and pairwise schemes, using a 9-point scoring system. Among them, 1 point indicates that a is not very advantageous compared to b, and 9 points indicate that a is very advantageous compared to b. Therefore, the higher the score, the greater the advantage of a

compared to b. Therefore, through pairwise comparison, the Analytic Hierarchy Process can establish pairwise comparison matrices as follows.

$$A = \begin{pmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & \vdots & \vdots & \vdots \\ \vdots & \vdots & \vdots & \vdots \\ a_{n1} & \cdots & \cdots & a_{nn} \end{pmatrix} \quad (1)$$

(3) Weight vector

Paired comparison matrix is used to compare each criterion against the main objective, or each scheme against a certain criterion. Therefore, it is necessary to normalize the comparison matrix to compare the score of each criterion or scheme under the corresponding main objective or criterion. After establishing a pairwise comparison matrix, the Analytic Hierarchy Process requires normalizing the columns and adding the rows of the comparison matrix to obtain a weight vector.

(4) Calculate the total sorting weight vector

After obtaining the weight vectors, the composite priority weights of the alternative layer relative to the main objective layer are calculated by multiplying these weights with the weight vectors from the higher-level layer (e.g., criteria layer). Based on the scores derived from the composite priority weights, the Analytic Hierarchy Process (AHP) identifies the optimal alternative and provides decision support to stakeholders.

4. Selection of Audit Blockchain Service Providers Based on Analytic Hierarchy Process

4.1 Selection criteria for blockchain service providers

This article analyzes the application of blockchain technology in audit work from the perspectives of cost and technology. Through summarizing and analyzing, it is believed that the following two criteria and four sub criteria are the most important factors that enterprises should consider when making decisions on blockchain suppliers.

(1) Cost criteria

Price: As a profit oriented economic entity, price is a factor that enterprises must consider when purchasing. In auditing blockchain services, enterprises need to pay a certain cost for purchasing services from suppliers, and the level of this cost will have a significant impact on the decision-making of the enterprise.

(2) Technical guidelines

Technical completeness: Technical completeness refers to the overall level of technical support provided by blockchain service providers. If the blockchain technology of the service provider is very comprehensive, it will provide important technical support for our enterprise to use blockchain. On the one hand, it will strengthen data security, make blockchain information more complete, and on the other hand, it will enhance audit efficiency and improve audit accuracy.

Personalized development capability: Blockchain technology is a new technology for enterprise operations, and employees' proficiency in using blockchain not only depends on their abilities, but also on the corresponding personalized page design. Good supplier personalized development capabilities are beneficial for companies to design work interfaces that are more in line with their employees' work experience, thereby significantly improving work efficiency.

Post maintenance level: As an emerging technology, blockchain technology is inevitably prone to corresponding problems during use. A good level of post maintenance can provide logistical support for enterprises. On the one hand, from a technical perspective, it can ensure that the use of blockchain is safer and more effective. On the other hand, from a usage perspective, good after-sales service provides better instructions for enterprises and timely support for their operations.

4.2 Introduction to Blockchain Service Providers

There are numerous existing blockchain service providers. To verify the feasibility of the proposed Analytic Hierarchy Process model, this article selected three representative blockchain service providers as the selected subjects.

(1) Microsoft

As the leader of existing enterprises, Microsoft has technological advantages, but correspondingly, its prices are also higher. Microsoft launched Azure blockchain services in 2015, becoming one of the first software vendors in the world to offer BaaS. Last year, it launched enterprise smart contracts, providing users with architecture, logic, counterparties, external sources, ledgers, and contract bindings for building their own blockchain services. In November 2015, Microsoft and ConsenSys announced a partnership to create Ethereum blockchain services (EBaaS) on Microsoft Azure. This service aims to help customers build private, public, and consortium based blockchain environments on Microsoft Azure's global platform. One year later, Microsoft announced a collaboration with Blockstack Labs, ConsenSys, and various developers on a blockchain based open-source identity recognition system that allows people, products, applications, and services to interconnect across blockchain, cloud computing providers, and organizations.

(2) SAP

SAP is an established technology company with strong technology and moderate prices, belonging to the mid-range supply chain service provider. SAP's blockchain as a service is called "Leonardo", which is based on Hyperledger and located in SAP Cloud services, so it can be accessed from any device without the need for local hardware or software. SAP Leonardo serves as a blockchain cloud service, machine learning service, and supports the Internet of Things (IoT) within a single ecosystem.

(3) Only Chain

Weichain is an emerging blockchain service provider. Weichain is a globally leading blockchain commodity and information platform. By working with enterprise customers who are willing to explore and industry experienced partners, we aim to create a comprehensive blockchain solution that breaks down the barriers between blockchain technology and real business applications. We are committed to creating a trusted distributed business environment that is transparent, collaborative, efficient, and capable of high-speed value transmission. At present, Weichain has established solid cooperative relationships with many industry-leading enterprises, including PwC, DNV GL, Renault Group, KUEHNE+NAGEL, Shanghai Waigaoqiao International Liquor Exhibition and Trading Center, China Unicom, etc., and has accumulated rich experience in blockchain implementation in industries such as fashion, luxury goods, automotive, supply chain management, liquor traceability, and agriculture.

4.3 Establishing a hierarchical structure model

Based on the above analysis, this article establishes the following hierarchical structure model as shown in Figure 2. The main objective of the model is to select a suitable auditing blockchain service provider. Below the goal layer, this model judges and scores the achievement of the target through four sub criteria. At the scheme level, this article analyzes and scores three enterprises within the selected scope, and selects the optimal blockchain service provider based on the above analysis.

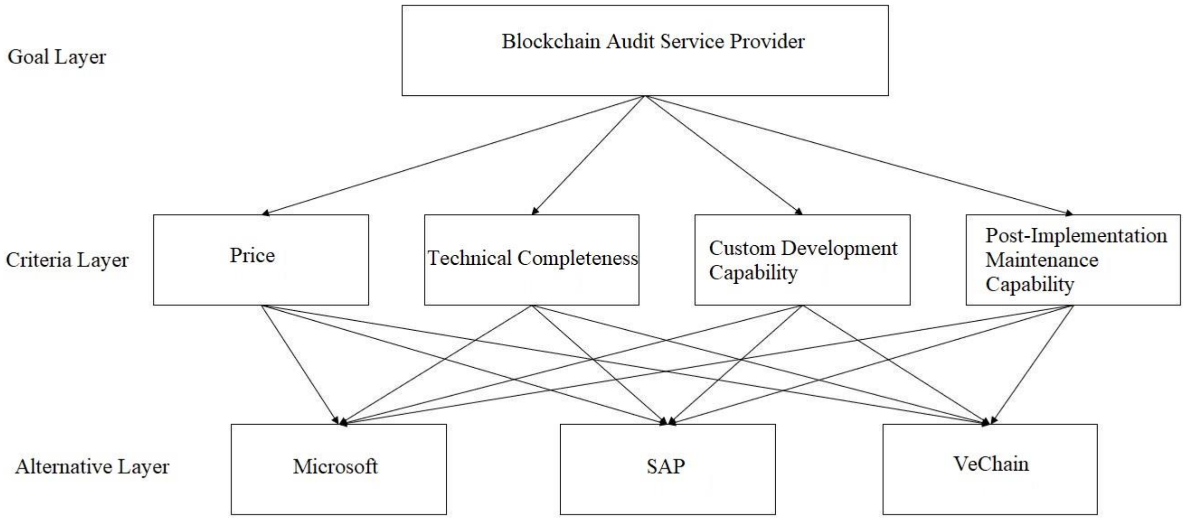

Figure 2. Hierarchical Structure Model of Audit Blockchain Service Providers

4.4 Paired comparison matrix

Regarding the weight analysis of the criteria layer relative to the objective layer, this paper establishes the pairwise comparison matrix A as follows

$$A = \begin{pmatrix} 1 & \frac{1}{5} & \frac{1}{3} & 7 \\ 5 & 1 & 3 & 3 \\ 3 & \frac{1}{3} & 1 & 3 \\ \frac{1}{7} & \frac{1}{3} & \frac{1}{3} & 1 \end{pmatrix} \tag{2}$$

Regarding the weight analysis of the alternative layer relative to the goal layer, this paper establishes the pairwise comparison matrices B_1, B_2, B_3, B_4 as follows:

On the price level, Microsoft is the leading enterprise, and the relative price will also be higher. On the other hand, as an emerging enterprise, Weichain has an advantage in price. Therefore, the scoring results on the price level are as follows.

$$B_1 = \begin{pmatrix} 1 & 3 & 5 \\ \frac{1}{3} & 1 & \frac{1}{3} \\ \frac{1}{5} & 3 & 1 \end{pmatrix} \tag{3}$$

In terms of technological completion, Microsoft, as an industry pioneer, has an advantage in technology, while correspondingly, only Chain may not be as technologically advanced as the other two companies. Therefore, the scoring results are as follows.

$$B_2 = \begin{pmatrix} 1 & \frac{1}{3} & \frac{1}{5} \\ 3 & 1 & \frac{1}{3} \\ 5 & 3 & 1 \end{pmatrix} \tag{4}$$

In terms of personalized development capabilities, Microsoft mostly provides standardized services, while correspondingly, Weichain is investing more resources in scale customization.

Therefore, the scoring results are as follows.

$$B_3 = \begin{pmatrix} 1 & 3 & 5 \\ \frac{1}{3} & 1 & 5 \\ \frac{1}{5} & \frac{1}{5} & 1 \end{pmatrix} \tag{5}$$

In terms of maintenance level in the later stage, SAP focuses on serving customers, and correspondingly, Microsoft has larger customer resources, making it more difficult to maintain customer resources. Therefore, the scoring results are as follows.

$$B_4 = \begin{pmatrix} 1 & 5 & 3 \\ \frac{1}{5} & 1 & 3 \\ \frac{1}{3} & \frac{1}{3} & 1 \end{pmatrix} \tag{6}$$

Normalize the column vectors of matrix A to obtain matrix $A^{'}$ as follows:

$$A' = \begin{pmatrix} 0.109 & 0.107 & 0.071 & 0.5 \\ 0.547 & 0.536 & 0.643 & 0.214 \\ 0.328 & 0.179 & 0.214 & 0.214 \\ 0.016 & 0.179 & 0.071 & 0.071 \end{pmatrix} \tag{7}$$

Normalize the row sum of matrix $A^{'}$ to obtain the weight vector w_A of the criterion layer to the Goal Layer as follows:

$$w_A = \begin{pmatrix} 0.787 \\ 1.94 \\ 0.935 \\ 0.337 \end{pmatrix} \tag{8}$$

To verify the consistency of the comparison matrix, this paper calculates the eigenvalues of the matrix as follows:

$$Aw = \begin{pmatrix} 1 & \frac{1}{5} & \frac{1}{3} & 7 \\ 5 & 1 & 3 & 3 \\ 3 & \frac{1}{3} & 1 & 3 \\ \frac{1}{7} & \frac{1}{3} & \frac{1}{3} & 1 \end{pmatrix} \begin{pmatrix} 0.787 \\ 1.94 \\ 0.935 \\ 0.337 \end{pmatrix} = \begin{pmatrix} 3.846 \\ 9.691 \\ 4.954 \\ 1.408 \end{pmatrix} = \lambda w \tag{9}$$

The eigenvalue $\lambda = \frac{1}{4}\left(\frac{3.846}{0.787} + \frac{9.691}{1.94} + \frac{4.954}{0.935} + \frac{1.408}{0.337}\right) = 4.840$, and the consistency index $CI = \frac{\lambda - n}{n-1} = \frac{4.840-4}{4-1} = 0.28$,ccording to the table, the random consistency index $RI = 0.90$,Therefore, the consistency ratio $CR = \frac{CI}{RI} = \frac{0.28}{0.90} = 0.31$ is defined to be close to 0 and passes the consistency test.

Normalize the B_1 column vector to obtain the matrix $B_1^{'}$ as follows:

$$B_1^{'} = \begin{pmatrix} 0.652 & 0.429 & 0.789 \\ 0.217 & 0.143 & 0.053 \\ 0.130 & 0.429 & 0.158 \end{pmatrix} \tag{10}$$

Normalize the row sum of matrix $B_1^{'}$ 'to obtain weight vector w_{B_1} as follows:

$$w_{B_1} = \begin{pmatrix} 1.87 \\ 0.413 \\ 0.717 \end{pmatrix} \tag{11}$$

Normalize the B_2 column vector to obtain the matrix $B_2^{'}$ as follows:

$$B_2^{'} = \begin{pmatrix} 0.111 & 0.077 & 0.130 \\ 0.333 & 0.231 & 0.217 \\ 0.556 & 0.692 & 0.652 \end{pmatrix} \tag{12}$$

Normalize the row sum of matrix $B_2^{'}$ to obtain the weight vector w_{B_2} as follows:

$$w_{B_2} = \begin{pmatrix} 0.318 \\ 0.781 \\ 1.9 \end{pmatrix} \tag{13}$$

Normalize the B_3 column vector to obtain the matrix $B_3^{'}$ as follows:

$$B_3^{'} = \begin{pmatrix} 0.652 & 0.714 & 0.455 \\ 0.217 & 0.238 & 0.455 \\ 0.130 & 0.048 & 0.091 \end{pmatrix} \tag{14}$$

Normalize the row sum of matrix $B_3^{'}$ to obtain the weight vector w_{B_3} as follows:

$$w_{B_3} = \begin{pmatrix} 1.821 \\ 0.910 \\ 0.269 \end{pmatrix} \tag{15}$$

Normalize the B_4 column vector to obtain the matrix $B_4^{'}$ as follows:

$$B_4^{'} = \begin{pmatrix} 0.652 & 0.789 & 0.429 \\ 0.130 & 0.158 & 0.429 \\ 0.217 & 0.053 & 0.143 \end{pmatrix} \tag{16}$$

Normalize the row sum of matrix $B_4^{'}$ to obtain the weight vector w_{B_4} as follows

$$w_{B_4} = \begin{pmatrix} 1.87 \\ 0.717 \\ 0.413 \end{pmatrix} \tag{17}$$

4.5 Calculate the total sorting weight vector

The weight of Microsoft relative to the overall objective is $1.87 * 0.787 + 0.318 * 1.94 + 1.821 * 0.935 + 1.87 * 0.337 = 4.421$.

The weight of SAP relative to the overall objective is $0.413 * 0.787 + 0.781 * 1.94 + 0.910 * 0.935 + 0.717 * 0.337 = 2.933$.

The weight of VeChain relative to the overall objective is$0.717 * 0.787 + 1.9 * 1.94 + 0.269 * 0.935 + 0.413 * 0.337 = 4.641$.

The weight vector of the decision layer relative to the overall objective is $w = \begin{pmatrix} 4.421 \\ 2.933 \\ 4.641 \end{pmatrix}$, a where VeChain has the highest weight. Therefore, the final decision should select VeChain as the enterprise's blockchain audit service provider.

5. Conclusion

This study identifies that traditional auditing faces numerous unresolved issues. Under the blockchain perspective, the conventional auditing model—primarily relying on on-site audits supplemented by online audits—still suffers from drawbacks such as high costs, tedious groundwork, low efficiency, time lags, significant risks, and vulnerabilities to data tampering with insufficient security.The distributed data structure of blockchain ensures that data accounting and storage are not constrained by a fixed central hardware system, thereby embodying decentralization. This decentralized nature inherently grants blockchain tamper-resistant properties. Additionally, data on any blockchain node is synchronized across all other nodes, ensuring transparency. Consequently, the innovative "Blockchain + Auditing" workflow model can reduce data verification costs, enhance audit efficiency, and mitigate audit risks. By leveraging blockchain technology, auditors can integrate blockchain application systems with the audited company's blockchain data, supported by data analytics, to streamline audit processes, improve efficiency, and lower risks. This paper employs the Analytic Hierarchy Process (AHP) to guide enterprises in selecting blockchain service providers. Focusing on three providers—Microsoft, SAP, and VeChain—the study evaluates them across four criteria (price, technical completeness, custom development capability, and post-implementation maintenance). The results demonstrate that VeChain emerges as the optimal choice, providing enterprises with a methodological framework and practical case for selecting blockchain audit service providers. This validates the feasibility of applying AHP in blockchain service provider selection.

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