AN EVALUATION FRAMEWORK FOR BLOCKCHAIN SELECTION IN SUPPLY CHAIN

Birsen Karpak[1], Deepa Iyer[2], Ilker Topcu[3], Mustafa Sahin Aydin[4], Emre Turkmen[5]

Highlights

- **Comprehensive ANP Framework:** Developed to aid blockchain selection specifically for supply chain management.
- **Interdependency Consideration:** Emphasizes accounting for the interrelationships among blockchain enablers.
- **Impact Analysis:** Highlights the influence of alternative blockchain platforms on critical blockchain enablers.
- **Enhanced Applicability:** Critique frameworks that fail to incorporate platform impacts, noting their limited practical use.

1. Introduction

Blockchain technology has gained significant importance and acceptance in recent years. This paper seeks to develop a comprehensive framework for blockchain selection in supply chain management by identifying key enablers and analyzing their interdependencies. Selecting the right blockchain platform presents a substantial challenge for supply chains, primarily due to the limited availability of reliable evaluation frameworks. Moreover, the process often requires a deep understanding of technical aspects to ensure the chosen platform aligns with the specific needs of each application.

Blockchain technology functions as both a database and an application software layer that defines the data structure and governs how data is updated within the system. It enables the addition of new data while ensuring that all users on the network maintain an identical copy of the same. This distributed and decentralized linked data structure facilitates secure data storage and retrieval, offering strong resistance to unauthorized modifications. All participants in a blockchain network have full visibility into the transactions, promoting transparency and accountability. By digitizing transactions efficiently, blockchain accelerates processes, enhances operational efficiency, and improves transparency. It thus operates as a chain of cryptographically linked, timestamped blocks, serving as a distributed ledger where data is securely shared among network peers.

[1] Birsen Karpak, Youngstown State University, Ohio, USA, bkarpak@ysu.edu, https://orcid.org/0000-0001-8472-0598
[2] Deepa Iyer, Cleveland State University, Ohio, USA, d.iyer@csuohio.edu, https://orcid.org/0000-0001-6562-4402
[3] Ilker Topcu, Istanbul Technical University, Istanbul, Türkiye, ilker.topcu@itu.edu.tr, https://orcid.org/0000-0001-9717-7854
[4] Mustafa Sahin Aydin, Insanteknoloji, Istanbul Türkiye, sahin@insanteknoloji.com , https://orcid.org/0009-0007-5796-2007
[5] Emre Turkmen, Kocdigital, Istanbul Türkiye, emre.turkmen@kocdigital.com , https://orcid.org/0000-0003-4230-8807

2. Literature Review

Agi and Jha (2021) identify external pressure and relative advantage as the two most influential categories of blockchain adoption enablers in the supply chain. Existing research highlights numerous enablers, such as technical characteristics, technological infrastructure, resource support and maturity, economic considerations, market dynamics, and regulatory and legal environments, that must be considered when evaluating blockchain platforms like Ethereum Quorum or Hyperledger Fabric. However, previous studies often overlook the interdependencies among these enablers and the influence of alternative blockchain platforms on them. Since each platform has unique strengths, these differences significantly affect the selection of the "best" blockchain platform for a supply chain. Our research addresses this gap by proposing an Analytic Network Process (ANP) model that systematically evaluates and prioritizes these interactions, offering a comprehensive framework to determine the most suitable blockchain platform for specific supply chain needs.

Another significant limitation in the current research on blockchain selection is the assumption of a static "best" platform for the supply chain. In reality, the optimal choice can change as the influence of factors evolves. This underscores the need for models to incorporate sensitivity and robustness analyses to adapt to dynamic conditions. To the best of the authors' knowledge, no existing studies provide such an adaptable framework, further emphasizing the novelty and importance of this research.

3. Objectives

The research questions of our study are:

RQ 1. What factors influence the "best" blockchain selection for a particular supply chain?

RQ 2. What are the prominences of different factors affecting the "best" blockchain selection?

RQ 3. What are the priorities of alternative blockchain systems?

RQ 4. How sensitive are the results to the change in criteria prominence?

4. Research Design/Methodology

According to Saaty (2010), "The Analytic Hierarchy Process (AHP) is the thinking man's rational way to combine logic to identify connection among attributes and judgments to derive priorities from causal explanation. Its questions revolve around what dominates what and how strongly; it is expressed verbally and translated numerically using the absolute fundamental scale (p. xiii)" (Karpak, 2017). This perspective also applies to the ANP, as it factors in the specific method used to assess the strength of influence among various factors and determine the priorities of alternatives in decision-making. The ANP method has helped decision-makers tackle complex situations for more than two decades by considering how different factors influence each other within a decision model (Mu et al., 2020).

The Analytic Network Process (ANP) is used as the methodology of choice in our study. Enablers of blockchain adoption in the supply chain are identified using an extensive literature review and refined with industrial and academic experts. Blockchain platform adoption factors (BCPAF) and alternative blockchain platforms (PCP) are clustered into components. The

influence matrix of m+n by m+n is developed by consulting with decision-makers considering the developed selection factors and alternative blockchain platforms.

5. Data/Model Analysis

In our application, industry and academic experts employed a verbal scale for pairwise comparisons to evaluate criteria and alternatives. First, pairwise comparisons are assessed, and pairwise comparison matrices are created. Then, eigenvectors extracted from those matrices are placed in unweighted supermatrices. The final step involved deriving the Limit Matrix by raising the weighted supermatrix to successive powers until convergence was achieved. We utilized the SuperDecisions software (www.superdecisions.com) to compute the Limit Matrix and analyze the results.

While judgment inconsistencies can arise, we deploy a mathematical method to measure and address such inconsistencies, as outlined by Saaty (2013). This approach enables decision-makers to revise outlier judgments to acceptable levels or delay decisions until more consistent information becomes available. No decision delays were required in our case, as consistency indices generally remained within acceptable limits. On rare occasions when the index exceeded these limits, we solicited new judgments to resolve the inconsistencies.

Our methodology focused on eliciting expert judgments to determine alternatives' priority and the relative importance of criteria in decision-makers' perceptions. The consistency index proved instrumental in ensuring the robustness of these judgments, allowing us to accurately identify the prominences of factors influencing the selection of the “best” blockchain for supply chain adoption.

6. Limitations/Future Studies

In 2024, five key blockchain trends are reshaping industries: the role of AI in blockchain selection for supply chain management, blockchain integration with IoT, green blockchain initiatives, applications of blockchain in vaccine manufacture and tracking, and NFTs expanding beyond online art. Among these, AI’s influence on blockchain selection in supply chains stands out as a critical yet underexplored area. Studies by Tsolakis et al. (2023) and Ressi et al. (2024) emphasize how AI and blockchain can work together to address operational and technical challenges while fostering sustainability. AI-powered smart contracts, for instance, dynamically adjust terms using real-time data, enhancing adaptability and efficiency in supply chain operations.

Platforms like Ethereum Quorum and Hyperledger Fabric demonstrate significant potential when augmented with AI-driven functionalities. These capabilities enable supply chains to overcome scalability, security, consensus, and interoperability challenges.

We are likely to see a great deal of emphasis on attempts to “greenify” blockchain by moving to less energy-intensive models of blockchain technology – typically those that rely on “proof-of-stake” (POS) algorithms rather than “proof-of-work” (POW) to generate consensus.

7. Conclusions

This study advances organizational blockchain selection research by shifting the focus beyond dyadic interactions to a **network-based analysis of selection criteria**. The ANP

model offers a structured, quantifiable approach to prioritizing and understanding complex interdependencies, addressing critical theoretical and practice gaps. The results will guide stakeholders in designing **integrated, context-sensitive interventions** that enhance the sustainability of global supply chains.

We contend that decision-making is a learning process. The methodology and the decision support systems we suggest will help decision-makers in this process.

8. Key References

Agi, M.A. and Jha, A.K., (2022). Blockchain technology in the supply chain: An integrated theoretical perspective of organizational adoption. *International Journal of Production Economics, 247, p.108458.* https://doi.org/10.1016/j.ijpe.2022.108458

Hughes, L., Dwivedi, Y.K., Misra, S.K., Rana, N.P., Raghavan, V. and Akella, V., (2019). Blockchain research, practice, and policy: Applications, benefits, limitations, emerging research themes and research agenda. *International Journal of Information Management, 49,* pp.114–129. https://doi.org/10.1016/j.ijinfomgt.2019.02.005

Karpak, B. (2017). Reflections: Mathematical principles of decision making. *International Journal of the Analytic Hierarchy Process*, *9*(3). https://doi.org/10.13033/ijahp.v9i3.521

Mu, E., Cooper, O., & Peasley, M. (2020). Best practices in Analytic Network Process studies, *Expert Systems with Applications, 159*, 113536. https://doi.org/10.1016/j.eswa.2020.113536.

Ressi, D., Romanello, R., Piazza, C., & Rossi, S. (2024). AI-enhanced blockchain technology: A review of advancements and opportunities. *Journal of Network and Computer Applications*, 103858. https://doi.org/10.1016/j.jnca.2024.103858

Saaty, T. L. (2010). Mathematical principles of decisions making. Pittsburgh: RWS Publications

Saaty, T. L. (2013). The Modern Science of Multicriteria Decision Making and Its Practical Applications: The AHP/ANP Approach. *Operations Research*, *61*(5), 1101–1118. https://doi.org/10.1287/opre.2013.1197

Tsolakis, N., Schumacher, R., Dora, M., & Kumar, M. (2023). Artificial intelligence and blockchain implementation in supply chains: a pathway to sustainability and data monetization. *Annals of Operations Research*, *327*(1), 157-210. https://doi.org/10.1007/s10479-022-04785-2