Identification and Analysis of Barriers to the Adoption of Blockchain Technology in the Logistics Industry

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Abstract

The global logistics industry is facing increasing complexity, making effective logistics management crucial for reducing costs and gaining a competitive edge. Blockchain technology emerges as a potential solution, enhancing supply chain transparency and traceability for Thailand's logistics sector. However, understanding implementation challenges is crucial before investing in blockchain. This study analyzes obstacles using the index of item objective congruence (IOC) technique and expert opinions. The findings identify seven significant barriers: lack of awareness, lack of trust, lack of government support, lack of top management support and organizational policy, collaboration and network establishment issues, lack of operational standards, and technical challenges. The lack of government support ranks highest, highlighting the need for early consideration of regulatory standards and policies. These findings provide valuable guidance for organizations aiming to embrace digital transformation through blockchain implementation.

Keywords
Blockchain technology, Supply chain management, Logistics, Barriers, IOC

1. Introduction
Logistics involves overseeing the movement of products, information, and other resources from their point of origin to their intended destination. It encompasses activities such as information transfer, transportation, inventory management, raw material administration, and packaging. In the business realm, effective logistics management plays a vital role in cost reduction, revenue enhancement, and fostering trustworthy relationships with customers. Regardless of the industry, logistics is an indispensable function as long as goods are manufactured (Jwd Group 2023). Therefore, the logistics industry has garnered increased interest from numerous participants in the supply chain. As the logistics system becomes more complex, efficiency declines, and the demand for transparency rises (Canorea 2023).

The COVID-19 pandemic has greatly impacted Thailand's logistics industry, with international giants outperforming local companies due to superior supply chain management. Compared to transportation expenditures, the Thai logistics industry exhibits a 14.1% higher ratio of logistics expenses to gross domestic product (GDP) than the regional average. Therefore, the Thai logistics industry should focus on reducing transportation costs and rapidly improving transportation infrastructure to enhance its overall efficiency. Utilizing technologies that integrate transport data to address logistics challenges presents another opportunity to reduce costs and foster the development of logistics performance (Marketeer 2023).

Blockchain technology is now recognized as a potentially transformative technology that can revolutionize organizational operations, especially in light of the ongoing digitalization trend that has the potential to disrupt various businesses (Nagariya et al. 2022). With its decentralized and immutable ledger, blockchain technology simplifies asset monitoring and transaction recording, thereby reducing risk and increasing efficiency for all participants in the business chain. This enables organizations to enhance their work effectiveness (International Business Machines 2023). The implementation of blockchain technology is expected to have a positive impact on supply chains and the logistics industry, as it has the potential to reduce costs and improve information flow among supply chain participants (Hackius and Petersen 2020).

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Although blockchain technology has the potential to revolutionize sharing information and improve supply chain performance, many firms, especially those from developing countries, have not yet adopted it. The review of relevant literature also reveals a lack of studies that have examined barriers to the adoption of blockchain in the logistics industry.

1.1 Objectives

The objective of this study is to pinpoint the barriers that hinder the adoption of blockchain technology in the logistics sector in Thailand. The findings can serve as a comprehensive guideline to support decision-making by identifying potential obstacles for organizations that are interested in implementing blockchain technology to support their logistics operations.

2. Literature Review

A. Potential blockchain applications in the logistics sector

Blockchain technology is a revolutionary tool that has the potential to completely transform supply chains and logistics networks. Alongside other digital innovations, it can address transit challenges, manage demand fluctuations, minimize sales losses, and enhance confidence and transparency. By providing an encrypted digital record, blockchain enables comprehensive product monitoring throughout the supply chain, streamlines verification processes, reduces paperwork, and facilitates end-to-end tracking. It can track a product's life cycle and ownership transfers while also offering a decentralized public documentation system for real-time recording of all changes. This empowers businesses to adopt more efficient routes, reduce transportation steps, decrease error rates, and save time. Furthermore, this technology has the capacity to improve the profitability of businesses in the logistics sector (Canorea 2023; Chavalala et al. 2022; Brown 2016; Alqarni et al. 2023).

Blockchain technology provides a secure platform for organizations to share data, offering protection against fraud as data cannot be altered once recorded on the ledger. It utilizes a shared and distributed ledger, ensuring a single source of truth for product information throughout the supply chain. Participants can contribute and control access to their data, enhancing transparency and information exchange. This enables customers to make informed decisions and supply chain participants to access open information about manufacturing and transportation. Additionally, blockchain technology enhances customer trust by providing indisputable evidence of the origin of raw materials, products, and their sale to end customers. It also acts as a deterrent to counterfeit goods and protects intellectual property rights, increasing consumer confidence and profitability. The ability to trace products back to their source is highly valued by regulatory agencies and customers, particularly in industries susceptible to counterfeiting, providing a competitive advantage (Alqarni et al. 2023; International Business Machines 2021).

A smart contract is a widely used blockchain application that consists of pre-programmed rules. It ensures smooth operations and adherence to agreed-upon service and product quality standards. Deployed on the blockchain, a smart contract serves as an enforceable agreement within a logistical supply chain system. It outlines communication guidelines between participants and operates automatically when all specified conditions are met. (Alqarni et al. 2023; BlockchainHub 2023). Smart contracts simplify and increase the security of several logistics-related processes, including contract terms, fraud prevention, record keeping, payments, cash flow, and others. Due to the absence of middlemen or third-party processors, they also save money (Upstate Interactive 2023). Figure 1 shows the benefits and traits of a smart contract, including its lack of middlemen, trustlessness, autonomous execution, cost-effectiveness, use of code as the authority, and distributed safe backup. Figure 2 shows how smart contracts are used in a logistics and supply chain scenario (Alqarni et al. 2023).

Several participants can interact with blockchain technology with less risk and trust. Depending on the application, it may be either public or private. By using blockchain, all parties may operate more efficiently by reducing paperwork, improving warehouse management, reducing delivery costs, reducing latency, anticipating demand and supply, and promptly spotting and fixing problems. It is anticipated that this technology will increase both global trade and GDP (Alqarni et al. 2023).

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Figure 1. The features of a blockchain system smart contract (Alqarni et al. 2023).

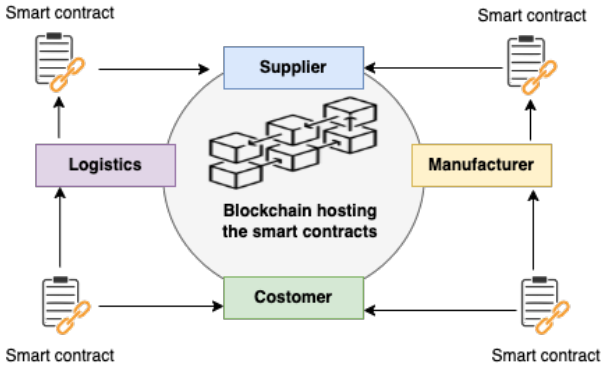

Figure 2. The use of smart contracts in a supply chain and logistics scenario (Alqarni et al. 2023).

B. Potential Barriers

According to the review of 12 published articles that focused on investigating barriers to the implementation of blockchain in many sectors (Nagariya et al. 2022; Chavalala et al. 2022; Kumar et al. 2022; Panghal et al. 2022; Kouhizadeh et al. 2021; Farooque et al. 2020; Lohmer and Lasch 2020; Toufaily et al. 2021; Boutkhoum et al. 2021; Rathore et al. 2022; Zhang and Song 2022; Esmaeilian et al. 2020) 14 potential barriers or difficulties can be identified, as follows:

1. **Lack of Awareness (B1):**
There is the public's limited awareness of blockchain technology, coupled with pessimistic attitudes, the uncertain consumer behavior with the increasing prices of products and accountability services (Nagariya et al. 2022; Kumar et al. 2022; Panghal et al. 2022; Kouhizadeh et al. 2021; Farooque et al. 2020; Lohmer and Lasch 2020; Toufaily et al. 2021).

2. **Lack of Trust (B2):** The lack of trust in the blockchain manifests in the handling of data sharing among all participants in the supply chain. At times, there exists crucial data that necessitates sharing with other organizations within the supply chain. Consequently, numerous challenges arise in terms of security, privacy, reliability, hacking, and fraud (Nagariya et al. 2022; Chavalala et al. 2022; Kumar et al. 2022; Panghal et al. 2022; Kouhizadeh et al. 2021; Farooque et al. 2020; Lohmer and Lasch 2020; Toufaily et al. 2021; Boutkhoum et al. 2021; Rathore et al. 2022; Zhang and Song 2022; Esmaeilian et al. 2020).

3. **Lack of Infrastructure (B3):** The internet, IT infrastructure, and various tools are essential components for blockchain adoption (Chavalala et al. 2022; Kumar et al. 2022; Panghal et al. 2022; Kouhizadeh et al. 2021; Farooque et al. 2020; Lohmer and Lasch 2020; Boutkhoum et al. 2021; Rathore et al. 2022).

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4. **Lack of skills (B4**): There might be a lack of relevant high-tech knowledge, technical expertise, worker competency, and IT skills. Moreover, the complexity of blockchain system creation, maintenance, and operation needs to be considered before starting to use the technology (Nagariya et al. 2022; Chavalala et al. 2022; Kumar et al. 2022; Panghal et al. 2022; Kouhizadeh et al. 2021; Lohmer and Lasch 2020; Boutkhoum et al. 2021; Rathore et al. 2022; Zhang and Song 2022).

5. **Lack of government support (B5)**: Insufficient government support has hindered the development and evaluation of critical aspects such as security, health, and the economy in the adoption and utilization of IT. Consequently, adopting blockchain technology requires careful consideration of appropriate regulatory standards, government policies, legal permissions, and digital policies (Nagariya et al. 2022; Chavalala et al. 2022; Kumar et al. 2022; Panghal et al. 2022; Kouhizadeh et al. 2021; Farooque et al. 2020; Lohmer and Lasch 2020; Toufaily et al. 2021; Boutkhoum et al. 2021; Rathore et al. 2022; Zhang and Song 2022; Esmaeilian et al. 2020).

6. **Lack of top management support and organization policy (B6):** The adoption of big data and blockchains is hindered by a lack of management support, investment, and long-term commitment. Additionally, businesses face challenges when there are no organizational policies regarding the use of blockchain technology. Moreover, the absence of additional supporting advantages (incentives) exacerbates the situation (Nagariya et al. 2022; Chavalala et al. 2022; Kouhizadeh et al. 2021; Farooque et al. 2020; Lohmer and Lasch 2020; Toufaily et al. 2021; Boutkhoum et al. 2021; Rathore et al. 2022).

7. **Hesitation to Convert to new Systems (B7):** The adoption of blockchain technology brings about changes and modifications to existing organizational culture, which can result in resistance and hesitation from employees and organizations. Organizational culture encompasses guidelines for work culture and appropriate behaviors across the organization (Nagariya et al. 2022; Chavalala et al. 2022; Farooque et al. 2020; Boutkhoum et al. 2021; Rathore et al. 2022).

8. Issues with Collaboration and Network Establishment (B8): Lack of collaboration, agreement, and coordination within an organization and among supply chain partners can impede the acceptance of blockchain technology (Chavalala et al. 2022; Kumar et al. 2022; Panghal et al. 2022; Kouhizadeh et al. 2021; Farooque et al. 2020; Lohmer and Lasch 2020; Toufaily et al. 2021).

9. **High Cost (B9):** Blockchain adoption requires substantial investment and resources, such as the costs of high energy consumption, more training, audits and re-certification on the ground to ensure compliance (Nagariya et al. 2022; Chavalala et al. 2022; Kumar et al. 2022; Panghal et al. 2022; Kouhizadeh et al. 2021; Lohmer and Lasch 2020; Toufaily et al. 2021; Boutkhoum et al. 2021; Zhang and Song 2022; Esmaeilian et al. 2020).

10. Lack of Operation Standards for Blockchain (B10): There is a lack of operational guidelines, an industry standard, suitable indicators, techniques, and approaches for implementing blockchain technology (Kumar et al. 2022; Kouhizadeh et al. 2021; Lohmer and Lasch 2020; Zhang and Song 2022).

11. **Technical Challenges (B11):**
Limited access to hardware poses a technical challenge for collecting real-time supply chain data. To overcome this, a robust data management system is essential to tackle issues related to storage, data transfer, scalability, and miner node density. Even if an incorrect record on the blockchain is updated with new information, its historical presence persists. This characteristic highlights the technological immaturity of the system (Kumar et al. 2022; Panghal et al. 2022; Kouhizadeh et al. 2021; Farooque et al. 2020; Lohmer and Lasch 2020; Toufaily et al. 2021; Boutkhoum et al. 2021; Rathore et al. 2022).

12. **Lack of Competitive Force (B12):** There is no pressure to adopt this technology as competitors have not invested in it, resulting in a lack of incentive for investment in a new one (Farooque et al. 2020).

13. **Environment Effect (B13):** Environmental issues arise from the increasing electricity and energy consumption associated with blockchain technology, which can lead to higher carbon emissions (Chavalala et al. 2022; Kouhizadeh et al. 2021; Farooque et al. 2020; Boutkhoum et al. 2021; Zhang and Song 2022; Esmaeilian et al. 2020).

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14. **Acceptance of Cryptocurrencies (B14):** Usage of cryptocurrencies (tokens) might not be accepted. The percentage of organizational adoption of public blockchains is associated with the adoption of cryptocurrency usage (Lohmer and Lasch 2020; Toufaily et al. 2021).

3. Methods

After identifying the 14 potential barriers through a review of relevant literature, it is still needed to validate them to ensure that they are significant for logistics practitioners in Thailand. The validation was based on the interviews of eight specialists who have experience and knowledge in the logistics field or blockchain by using the index of item-objective congruence (IOC) approach. The specialists include four managers and directors of famous logistics companies in Thailand; a technology director and a project development director from a technological company that is operating on blockchain technology in Thailand; and two university lecturers who have published articles about blockchain technology applications in supply chain management in Thailand.

The IOC method was first introduced by Rovinelli and Hambleton in 1977. This method evaluates the match between items and objectives, which is the most important assessment during the content validation stage (Ismail and Zubairi 2021). This approach offers quantitative scores to suggest improvements through responses to expert judgments (Nantee and Sureeyatanapas 2021). The extent to which the tool measures what is intended to be evaluated is the content validity, which is the most significant validity. Expert judgment is the practical method for determining the content truth. Each item should be subject to evaluation by at least five specialists to determine whether each barrier truly supports consistency of implementation in the adoption of blockchain technology in the logistics sector (Nantee and Sureeyatanapas 2021). There are two phases in the IOC stages (Nantee and Sureeyatanapas 2021; Mathong et al. 2020; Ismail and Zubairi 2021) as follows:

1. Each barrier is evaluated by an expert, who assigns it a score of 1, -1, or 0.

- The score is 1 if the expert is sure that this barrier is relevant to the logistics sector's implementation of blockchain technology.
- The score is -1 if the expert is sure that this barrier is not relevant to the logistics sector's implementation of blockchain technology.
- The score is 0 if the expert is not sure whether the barrier is relevant to the logistics sector's implementation of blockchain technology or not.

2. The outcomes of the experts' ratings are averaged to produce the IOC index for each obstacle. The index values below 0.5 indicate that the object is unfit and needs to be removed from the list, while those between 0.5 and 1.00 indicate that it is significant and needs to be considered further.

4. Results and Discussion

The results of interviewing eight experts using the IOC approach were presented in Table 1. Figure 3 indicated that only seven barriers were considered significant, with an average IOC index value equal to or greater than 0.5. The following barriers, lack of infrastructure (B3), lack of skills (B4), hesitation to convert to new systems (B7), high cost (B9), lack of competitive force (B12), environmental effect (B13), and acceptance of cryptocurrencies (B14), were excluded from the list. Their IOC index values below 0.5 indicated that these barriers were not relevant to Thailand's logistics sector.

According to most specialists, the lack of infrastructure (B3) was not considered a significant barrier for the Thai logistics industry. They believed that the existing infrastructure was sufficiently robust, and even if it was not fully developed, it could be easily supplemented when necessary. The lack of skills (B4) was a concern primarily in the early stages of adopting blockchain technology since it was relatively new. However, as the technology became more widespread, its impact on skill requirements diminished. At the time, a few companies in Thailand had developed blockchain systems to serve organizations in need of such technology. The custom applications were designed to be user-friendly, making them easy for users to operate without requiring extensive skills. According to the majority of specialists, the hesitation to convert to new systems (B7) was considered a minimal barrier in implementing blockchain technology within the Thai logistics industries. This sector already embraced various innovations and technologies to

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streamline their processes and enhance convenience. In fact, many executives may not even consider this aspect as a significant concern. High cost (B9) was considered a relatively insignificant barrier, according to most experts, as blockchain technology offered numerous cost-saving opportunities. For instance, adopting e-documents and other paperless solutions could help reduce expenses significantly. When comparing the payback period and benefits, blockchain technology demonstrated a positive outcome. Furthermore, as mentioned earlier, a few companies in Thailand had already developed ready-made blockchain systems, eliminating the need for substantial investments by interested companies. The lack of competitive force (B12) was not considered a significant barrier because most experts believed that the advantages of technology were more important. When competitors did not decide to use blockchain, it became beneficial to the organization to gain a competitive advantage. Based on the interviews conducted, the majority of experts did not express any concern regarding the environmental impact (B13). This was attributed to the presence of various corporate social responsibility (CSR) initiatives among organizations in the logistics sector. Additionally, blockchain technology offered multiple alternative algorithms, some of which required only a few minutes to execute. Consequently, energy consumption was relatively low, resulting in low quantitative carbon emissions. In regard to the acceptance of cryptocurrencies (B14), there existed confusion among people in Thailand regarding blockchain and cryptocurrencies. It was essential to clarify that blockchain and cryptocurrencies were separate entities. Thus, the acceptance of cryptocurrencies (B14) was not considered a barrier by most experts, as blockchain technology usage was unrelated to the acceptance of cryptocurrencies.

Table 1. The results of IOC approach.

Barriers	Expert1	Expert2	Expert3	Expert4	Expert5	Expert6	Expert7	Expert8	IOC index
B5	1	1	1	1	1	1	1	1	1.00
B1	1	1	0	1	1	1	1	1	0.88
B10	1	1	0	1	1	0	1	1	0.75
B11	-1	1	1	1	1	1	1	1	0.75
B6	1	1	1	1	0	1	-1	1	0.63
B8	0	1	1	1	1	0	-1	1	0.50
B2	1	-1	1	1	-1	1	1	1	0.50
B4	1	1	0	1	-1	1	-1	1	0.38
B12	-1	1	1	0	0	1	1	-1	0.25
B3	-1	-1	1	-1	-1	0	0	1	-0.25
B14	-1	1	-1	1	-1	0	-1	0	-0.29
B9	-1	-1	-1	0	1	-1	-1	1	-0.38
B13	-1	-1	-1	1	-1	-1	-1	1	-0.57
B7	-1	-1	-1	-1	-1	0	-1	-1	-0.88

When gaining a thorough grasp of blockchain technology became the main priority for most experts, a lack of awareness (B1) became one of the major roadblocks. The majority of Thais were unaware of the potential of blockchain. Some individuals believed that blockchain and cryptocurrencies were the same thing. Whether blockchain technology could be used in the enterprise was impacted by an unclear understanding. While a few experts argued that blockchain technology demonstrated inherent trustworthiness, leading them to believe that the lack of trust (B2) might not be a major barrier, the prevailing consensus among many experts was that the lack of trust remained a significant obstacle. Trust served as a fundamental prerequisite for making decisions, and it was crucial for establishing a strong foundation before undertaking any endeavor. Additionally, the availability of reliable data were essential for achieving high levels of success, as it directly impacted profitability and the overall resilience of a company. For all experts, a big barrier was a lack of government support (B5). According to the experts, many logistics activities required coordination with a government agency. To ensure that blockchain technology was implemented properly, the government had to take into account the proper regulatory standards, legal permissions, and digital policies.

Some experts argued that the lack of organization policy and top management support (B6) might not be an obstacle to deploying blockchain because most top management was now willing to accept this technology if it benefited the entire value chain. In such cases, they were ready to listen and had a solid grasp of such technology. However, the majority of experts continued to believe that a lack of top management support and organizational policy was one of

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the primary barriers. This was because top management was the one who made decisions for the organization, so if they were not interested in or indifferent to blockchain, the implementation would never happen.

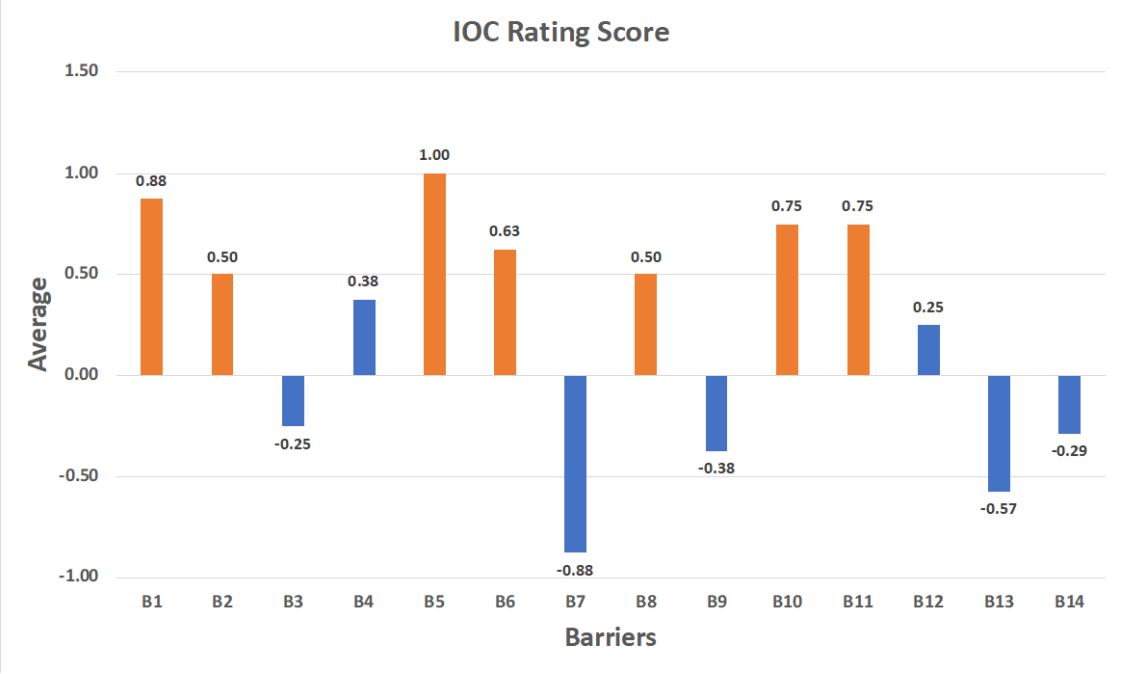

Figure 3. The summary of IOC index value.

Issues with collaboration and network establishment (B8) were considered a relatively big barrier when most experts believed that, to use blockchain at full capacity by making the data flow in real-time and providing more effective services, all parties needed to be involved in data sharing. On the other hand, one expert said that for a supply chain, only the major nodes needed to collaborate, but for other minor nodes, just sending the information was enough, and they did not need to invest in blockchain. The lack of operation standards for blockchain (B10) was widely acknowledged by experts as a major barrier to the adoption of blockchain technology in the Thai logistics industry. This obstacle arose because without established standards, companies might struggle to learn from Thailand's best practices and actual use cases, impeding their ability to effectively harness the potential of blockchain. Technical challenges (B11) were considered a relatively significant barrier. According to most experts, blockchain technology was the newest technology, and the technological immaturity of the system might pose technical challenges such as a system scalability problem, lack of function that protects incorrect records from entering the system, and others.

5. Conclusions

This study has identified and analyzed the barriers to the adoption of blockchain technology in the logistics industry in Thailand. Initially, a preliminary list of barriers was created by reviewing relevant literature covering various industries. The significant barriers that fit the specific circumstances of the logistics industry in Thailand were validated using the IOC technique through interviews with experts from both academic and industry sectors who possess experience in logistics and blockchain technology in Thailand. From the preliminary list of 14 barriers, seven remained significant based on their average IOC scores exceeding 0.5. They include lack of awareness (B1), lack of trust (B2), lack of government support (B5), lack of top management support and organizational policy (B6), issues with collaboration and network establishment (B8), lack of operational standards for blockchain (B10), and technical challenges (B11).

The findings provide valuable guidance for Thai logistics companies interested in implementing blockchain technology, enabling them to address the identified barriers and enhance the effectiveness of their processes. Notably, government support emerged as the most concerning barrier among the experts, as indicated by the highest IOC index score. This suggests that appropriate regulatory standards, government policies, legal permissions, and digital policies should have been carefully considered from the early stages of implementation.

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This study is a pilot study aiming to screen for significant barriers to the implementation of blockchain technology in the logistics industry in Thailand. A future study will investigate and establish the hierarchical relationships among these seven barriers by using the interpretive structural modeling (ISM) method.

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