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Modelling the Barriers to Blockchain Adoption in Tourism Industry based on ISM and Fuzzy DEMATEL Approach

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A R T I C L E I N F O

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A B S T R A C T

This study aims to identify and rank the key barriers hindering the adoption of Blockchain technology in the tourism industry, given its transformative potential and strategic relevance. The research utilized a mixed-method approach. First, barriers were identified through a comprehensive literature review and expert interviews. A sample of 22 experts in Blockchain and tourism was selected, and data were collected using a structured questionnaire. The Interpretive Structural Modeling (ISM) technique was employed to prioritize the barriers, and Decision-Making Trial and Evaluation Laboratory (DEMATEL) method was used to analyze the causal relationships among them. The study identified 11 critical barriers to Blockchain adoption in tourism. Among these, "the lack of knowledge, expertise, and human capital," "the lack of standardization," "the absence of government regulations," and "inadequate employee training and customer awareness" emerged as the most significant factors. Furthermore, "resistance to change and non-acceptance by companies" was found to have the highest level of interaction with other barriers, indicating its central role in the adoption process. This research contributes to the limited body of knowledge on Blockchain implementation in tourism by offering a systematic prioritization and relational mapping of adoption barriers. The findings provide strategic insights for policymakers, tourism stakeholders, and technology developers aiming to facilitate Blockchain integration in this sector.

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1. Introduction

Is it possible to overcome the barriers of Blockchain adoption and boost the tourism industry? Tourism is characterized by different actors, such as hoteliers, airline companies, travel agents, tour operators, insurance firms, payment service providers, and others, having complex business relationships and high competition. The tourism and hospitality industry has applied Blockchain since 2014 to increase the benefits for the actors involved in this sector (Irannezhad & Mahadevan, 2021). Using Blockchain jointly with other technologies, such as Information and Communication Technology (ICT), Artificial Intelligence (AI), smartphones, mobile devices, etc., can improve the quality of the services offered to customers (Rana et al., 2022). Blockchain is defined as decentralized ledgers that contain transactions as data blocks, with blocks linked to their predecessors by a cryptographic pointer. The chain continues to the originator, the first block. Whenever a new block is introduced to the system, it gets linked to its predecessor (Dinh et al., 2018). Due to its unique features, Blockchain technology can tremendously impact business processes and industries (Treiblmaier, 2020). The characteristics of Blockchain technology, such as reliability, traceability, data immutability, and smart contracts, give rise to trusted environments with less need for intermediaries (Iansiti & Lakhani, 2017). Blockchain is poised to take on competitors in the hotel industry, such as Airbnb and other online travel agencies (OTAs) platforms, such as Tripadvisor and Booking.com. Blockchain can provide advantages to travel industries and OTAs and boost the destinations' economy (Irannezhad & Mahadevan, 2021). The numerous potential benefits of Blockchain technology have not been empirically proven (Batubara et al., 2018). Moreover, the broader aspects of Blockchain application are yet to be discovered through governance models, impacts, risks, and key success factors (Ølnes et al., 2017). The potential of Blockchain technology to reduce costs leads to increasing process efficiency, reducing the risk of data fraud, increasing trust between business partners, and reducing the role of intermediaries in all business operations. Therefore, it is essential to study all aspects of Blockchain technology and its interactions within and between industries to better predict future changes in the tourism industry (Hughes et al., 2019). However, if the industry and users do not accept Blockchain technology, its potential to achieve these benefits will not be realized. Industry and user acceptance is a prerequisite for implementation success (Irannezhad & Mahadevan, 2021). Despite these potential benefits, the adoption rate of this technology has remained low (Kouhizadeh et al., 2021). Despite the benefits of Blockchain adoption in various fields, such as tourism, healthcare, supply chain, and the Internet of Things, Blockchain has been identified as a new technology or innovation. Therefore, it is essential to examine the barriers that prevent its implementation (Čižmešija & Vrček, 2021). The extant studies have highlighted several barriers to Blockchain adoption despite its perceived potential capabilities by stakeholders (Toufaily et al., 2021). Surveys show that Collaboration (Erol et al., 2022; Rashideh, 2020), the lack of full awareness of Blockchain technology (Erceg et al., 2020; Filimonau & Naumova, 2020; Melkić & Čavlek, 2020), the lack of relevant policies (Erceg et al., 2020; Kwok & Koh, 2019), technical immaturity (Erol et al., 2022), the lack of government regulation (Kwok & Koh, 2019; Sharma et al., 2021) and market immaturity (Kwok & Koh, 2019; Sharma et al., 2021) are among the most important challenges of Blockchain in the tourism industry (Kwok & Koh, 2019). Recent studies have highlighted that blockchain adoption in the tourism industry is constrained by a set of interrelated technological, organizational, and institutional barriers (Fathi et al., 2024).

Currently, extensive studies have been conducted on the application and benefits of Blockchain technology in the management and development of tourism. However, few research and empirical studies have been conducted on implementation problems and barriers to its acceptance in tourism. One of the most essential requirements for applying any technology is

to identify the barriers and challenges of its adoption. Therefore, to effectively use Blockchain, its challenges and barriers must be carefully identified and analyzed to minimize their adverse effects. Considering the future importance of Blockchain for tourism and the purpose of this research, that is to identify and rank the barriers to the adoption of Blockchain in the tourism industry, this research can be a timely contribution to other studies, practices, and policies required for the widespread adoption and implementation of Blockchain. In this research, the following questions have been addressed:

RQ1. What are the challenges and barriers of Blockchain adoption in the tourism industry?

RQ2. What are the most important challenges and barriers to Blockchain adoption in the tourism industry?

RQ3. What is the relationship between barriers?

This study uses the combined interpretive structural modeling (ISM) and decision-making trial and evaluation laboratory (DEMATEL) method to stratify and analyze the relationship between adoption barriers. This research used purposeful and judgmental sampling, and the methods questionnaire was provided to industry experts. This paper continues as follows: Section 2 reviews the literature on Blockchain in tourism. Section 3 introduces the research method. Section 4 presents the research findings. Section 5 analyzes the findings, and Section 6 presents the research conclusions.

2. Literature Review

2.1 Blockchain Technology

One of the fundamental innovations in decentralized information technology is Blockchain technology. Since 2008, Blockchain technology has been strongly associated with Bitcoin, and people say it was built as part of Bitcoin's underlying infrastructure. However, this technology goes beyond cryptocurrencies and financial assets. With the advancement of technology in successive years, use cases and applications for this technology have been created (Abeyratne & Monfared, 2016). Blockchain is a secure, decentralized public ledger in which each network member can view their transaction history, eliminating the necessity for a third party (Pilkington, 2016). Each block in the chain represents a network member's acknowledgment that a transaction took place and was not tampered. Furthermore, each block comprises information from the preceding block, which promptly builds a sequence of blocks (Nakamoto, 2008). Transactions are collected inside blocks that are appended to the Blockchain. Blocks are chained with cryptographic hashes (Conte de Leon et al., 2017). Each block (except the first) contains the previous block's hash. The Blockchain ensures integrity by chaining blocks of transactions together so that altering any block breaks the link with the next block (Varma, 2019). All the blocks together are called the ledger. A ledger is an auditable log of the entire transaction's history. In the ledger, each transaction is attached to a specific user code or pseudonym (Maxwell et al., 2017). There are currently three recognized types of Blockchain systems (Zheng et al., 2017): "Public Blockchain," where all records are publicly visible, with high immutability and low efficiency; "Private Blockchains," which belong to a specific organization, with less immutability but higher efficiency; "Blockchain Consortium" which is a combination of the previous two types of systems and not all users belong to the same organization. The immutability and efficiency are similar to the private Blockchain and are intermediate between decentralized public Blockchain and private centralized Blockchain in terms of centralization. According to Zheng et al. (2017), Blockchain has four key features:

• Decentralization: No need to distribute consensus algorithms in the Blockchain to maintain data stability in the network;

• Persistency: Fast confirmation of transactions and non-acceptance of invalid transactions by honest miners;

• Anonymity: Each user interacts with the Blockchain through a generated address without revealing the user's true identity;

• Auditability: Convenient transaction verification and tracking due to saving unspent referral transaction status history.

2.2 Applications and Opportunities of Blockchain in Tourism

The advancement of technology in information technology, especially Blockchain, creates enormous changes in the tourism industry. The application of Blockchain technology is multi-faceted; its implementation is set to benefit tourism in four broad areas. First, it enhances the tourist experience through learning based on Blockchain technology. Second, facilitating foreign exchange through cross-border remittances and real-time global digital currency pricing. Third, providing various tools to protect the currency and strengthen the banking system through Blockchain technology; and finally, reducing the overall operating cost by eliminating commission fees (Kwok & Koh, 2019). Treiblmaier (2020) describes the applications of Blockchain in tourism as follows: Inventory management," "Maintenance and Tracking," "Content, Reservations, and Ticketing," "Payments and Tax Compliance," "Loyalty Programs and Personalized Marketing," "Tokenization and Dedicated Coins," "Identity, Credential Management, and Privacy," "Baggage Tracking," "Smart Contracts," "Dapps for Smart Tourism," "Disintermediation," and "Coordination and Coopetition." Balasubramanian et al. (2022) argues that, in general, Blockchain applications in tourism can be divided into four categories. "Digitalization" uses digital technologies, such as Blockchain, to convert the physical ecosystem to a digital ecosystem and then manage it virtually. Tourism process "automation" on a global scale can be significantly driven by or facilitated by Blockchain, thereby increasing the sector's efficiency, accuracy, and productivity. "Disintermediation" increases accountability, transparency, trust, and collaboration among stakeholders in the tourism sector. Finally, Blockchain technologies can potentially enhance the "Intelligent environment" in the tourism sector.

2.3 Challenges of Blockchain Adoption in Tourism

With the increase of investment in new information and communication technologies, much attention has been paid to the acceptance of these technologies, and various researchers are trying to identify the influential factors in the acceptance of information technology. Acceptance is a multidimensional phenomenon and includes key variables such as perceptions, beliefs, attitudes, characteristics of people, and the level of involvement with information technology (Cheung et al., 2000). ICT is considered a key tool for achieving business competitiveness in organizations as the application of innovative IT solutions has significant positive effects on enterprise productivity (Čižmešija & Vrček, 2021). Some of the different models of technology acceptance include diffusion of innovations theory (DOI) (Rogers, 1961), the unified theory of acceptance and the use of technology (UTAUT), and the technology acceptance model (TAM). Kwok and Koh (2019) state the challenges of Blockchain as follows: consumer readiness and market maturity, political issues, the absence of regulation over blockchain and cryptocurrencies, and blockchain security concerns. In this regard, Zheng et al. (2017), despite the high potential of Blockchain, states that scalability, privacy leakage, and selfish mining challenges lead to the lack of widespread use of Blockchain. Besides technical barriers, numerous strategic challenges have occurred in Blockchain (BC) implementation since it is still a young and unexplored technology. Valeri and Baggio (2021) argue that there needs to be more academic research and practical cases of Blockchain implementation in the tourism

industry, and they propose increasing the interest of researchers in this subject. In particular, scholars have formulated some research proposals about its evolution and influence in the industry, concluding that the adoption of Blockchain technology and decentralized applications (DApps), will lead in the future to the creation of new business models and new market structures (Caddeo & Pinna, 2021). Fragnière et al. (2022) propose a step-by-step implementation for the soft adoption of Blockchain technology. They argued that the tourism industry is too fragmented and that adopting Blockchain technology could be the solution. However, the industry cannot implement it incrementally without government intervention, top-down research projects, practical examples of Blockchain-based businesses, and financial support. Treiblmaier (2021) also concludes that the root of all challenges related to Blockchain adoption is confusion due to a lack of awareness of this technology. He claimed that Blockchain is a "collective term" and includes several elements with specific functions; the impact of each element is different for the tourism industry, and it is not correct to discuss the overall impact of Blockchain technology. Rana et al. (2021) argued that the process is unlikely to be successful without preparing the ecosystem for Blockchain adoption in many countries. The full implementation and expansion of Blockchain technology in the tourism sector may require creating a central agency to develop a stable network of stakeholders, maintain it over time, and avoid potential illegal activities (Rashideh, 2020). On the other hand, Irannezhad Mahadevan (2020) argues that the systematization of these processes may cause the concentration and formation of new intermediaries in the tourism industry. Nam et al. (2021) state that the adoption of Blockchain technology, despite its distributed nature, may lead to the emergence of intermediaries in certain activities, such as offering coins/tokens in the case of digital currency expansion. Fragnière et al. (2022), propose the cooperation and competition of industry players through smart contracts under government governance. Prior research on blockchain implementation has identified critical adoption factors related to technological readiness, regulatory frameworks, and organizational capabilities (Fathi, 2021).

2.4 Research Background

Blockchain technology was first popularized by Nakamoto (2009), with the introduction of Bitcoin digital currency. Blockchain was initially focused on digital currencies and financial programs, but after a while, non-financial applications of Blockchain were also introduced to address various problems and issues; therefore, studies were conducted in various fields, particularly in the tourism industry. Numerous ressearchers have conducted studies regarding the identification and investigation of Blockchain adoption barriers in various industries, including banking, energy, supply chain and services (Alketbi et al., 2018; Al-Saqaf & Seidler, 2017; Atlam et al., 2018; Boulos et al., 2018; Crosby et al., 2016; Kouhizadeh et al., 2021; Lacity, 2018; Mendling et al., 2018; Reyna et al., 2018; Saheb & Mamaghani, 2021; Toufaily et al., 2021; Yildizbasi, 2021; Zheng et al., 2017). According to Rashideh (2020), the collaborative approach of all players in the tourism industry, including policymakers, service providers, marketers, and tourists, is a solution to overcome issues related to Blockchain adoption. However, collaboration is often challenging. In addition, Melkić and Čavlek (2020) believe that, while there is a lack of full understanding of Blockchain technology and a lack of awareness among stakeholders in the tourism industry, it will hardly achieve its potential to transform the sector. Erceg et al. (2020) identified a similar problem in the countries of Macedonia and Croatia that the barriers to the adoption of Blockchain are mainly related to the lack of relevant policies in the countries, the low awareness of actors in the tourism and environment sectors, that lack the readiness to adopt a system based on Blockchain. The findings of Erol et al.’s (2022) study show that "technical immaturity" and "lack of interoperability" are the most critical challenges of Blockchain in the tourism industry. Sharma

et al. (2021) state that there may be different challenges in adopting Blockchain in hospitality and tourism in both developed and developing countries. The study examined the countries of India and the Netherlands and concluded that "lack of government regulation" and "market immaturity" were the most critical barriers in India and in the Netherlands, respectively. Similarly, Filimonau and Naumova (2020) emphasized the problem of low awareness and confusion in the hospitality community about Blockchain technology and its potential for further development. This applies to the business sector as well as to policymakers. Kwok and Koh (2019) concluded that "market maturity," "political issues," "lack of regulations," and "energy consumption" are the most critical challenges of Blockchain adoption in the tourism industry. Decision-making techniques, such as DEMATEL, have also been widely applied in tourism-related studies to capture complex interdependencies among strategic factors (Fathi et al., 2022).

3. Methodology

3.1 Research Method

This research aims to identify and rank the barriers to Blockchain adoption in the tourism industry. In terms of purpose, this research is applied, and in terms of data collection, it is considered descriptive-survey type. The questionnaire tool and single-sample t-test were used to collect data to select the final barriers, and the interpretive structural modeling method and the fuzzy DEMATEL technique were used to analyze the data. Hybrid structural approaches, combining ISM and fuzzy DEMATEL, have been effectively applied to analyze complex causal relationships among decision variables in sustainability and technology-related contexts (Nasrollahi et al., 2023). The statistical population of this research consists of twenty-two university professors and experts in the tourism industry and Blockchain technology, as well as managers of hotels and tourism agencies in Tehran, who currently serve as professors or activists in the field of tourism. These experts have at least five years of research experience in the field of tourism and Blockchain technology, with at least a bachelor's degree, complete familiarity with the field of tourism, and sufficient knowledge and awareness of Blockchain technology. This research used the purposeful sampling method, and data collection was done in two stages. First, the barriers to acceptance were listed and finalized by reviewing the research literature and asking for experts' opinions. Then, to determine the relationship between barriers, the finalized barriers were provided to the experts using a questionnaire.

Interpretive Structural Modeling (ISM)

Interpretive structural modeling was used to analyze the effect of one element on other elements and examines the order and direction of complex relationships between the elements of a system. The methodology of interpretive structural modeling (ISM) acts as a tool for identifying relationships among specific items that define a problem or an issue (Sage, 1977; Warfield, 1974). This method defines the text relationship and the corresponding direction between parameters i and j. The following four symbols are used to represent the direction of the relationship between the parameters i and j (Chander et al., 2013):

(1) "V: parameter i will help to achieve parameter j"
(2) "A: parameter i will be achieved by parameter j"
(3) "X: parameters i and j will help achieve one another"
(4) "O: parameters i and j are unrelated"

The various steps in the ISM methodology are as follows (Charan et al., 2008):

(1) Variables affecting the system under consideration are listed.
(2) A contextual relationship is established among the variables identified in Step 1.

(3) A structural self-interaction matrix (SSIM) is developed, which indicates pairwise relationships among variables.

(4) The reachability matrix is developed from the SSIM and checked for transitivity.

(5) The reachability matrix obtained in Step 4 is divided into different levels.

(6) A directed graph is drawn based on the reachability matrix.

(7) The resultant digraph is converted into an ISM.

The reason for using the ISM method in this research is that ISM provides a systematic and oriented framework for complex problems and transforms unclear and weak mental models of systems into visible and well-defined ones. These models help to find the key factor associated with the problem or issue; once the key factor is identified, a strategy may be developed to address the issue.

DEMATEL

The DEMATEL technique was introduced by Geneva in 1973 to address complex and uncertain problems (Shieh et al., 2010). It is a comprehensive method for building and analyzing a structural model involving causal relationships between complex factors (Wu & Lee, 2007). This method transforms the relationships between the causes and effects of the criteria from an unpredictable model to a justifiable model of the selected system (Dalalah et al., 2011). Moreover, it is based on a diagram that can separate the involved factors into cause and effect groups and convert the relationship between the causes and effects of the factors into an understandable structural model of the system. Directed graphs in ISM are more valuable than directionless graphs as they can demonstrate the directed relationships of sub-systems (Wu & Lee, 2007). In this method, triangular fuzzy numbers, proposed by Lin and Wu (2008), have been used. Linguistic scales and triangular fuzzy numerical values corresponding to them are listed in Table 1.

Table 1

Linguistic Scales of DEMATEL Technique

Linguistic terms	Triangular fuzzy numbers
Very high impact (VH)	(1,1,0.75)
high impact (H)	(1,0.75,0.5)
low impact(L)	(0.75, 0.5 and 0.25)
very low impact (VL)	(0.5,0.25,0)
No effect (NO)	(0.25,0,0)

The analysis of this method includes the following steps (kouhizadeh et al., 2021):

Step 1- Aggregating results (average) and establishing pairwise direct-relation matrix

Step 2- Determining the initial influencing matrix (N) by normalizing

Step 3- Calculating the total relation matrix (T)

Step 4- Determining row and column sums from the total relation matrices

Step 5- Determining the overall prominence and net effect values of factors

Step 6- Drawing the DEMATEL prominence/effect diagrams

Considering the primary goal of the research, which is to identify and rank barriers and analyze the impact and effectiveness of barriers in adopting Blockchain in the tourism industry, the DEMATEL technique has been used in this research. DEMATEL is one of the best-applied

techniques to find the cause-and-effect relationship between the evaluated criteria in any system or product evaluation process. DEMATEL explores the causal dependency structure among identified factors and utilizes pairwise comparisons to visualize direct and indirect relationships among these factors. Therefore, it is a suitable method for mind-mapping studies (kouhizadeh et al., 2021) and helps structure the causal relationships among the identified barriers and define each barrier's prominence (Fu et al., 2012; Lee et al., 2010). Moreover, in the current study, a fuzzy approach has been used to reduce decision-maker judgment errors. This research process, as shown in Figure 1, includes five steps.

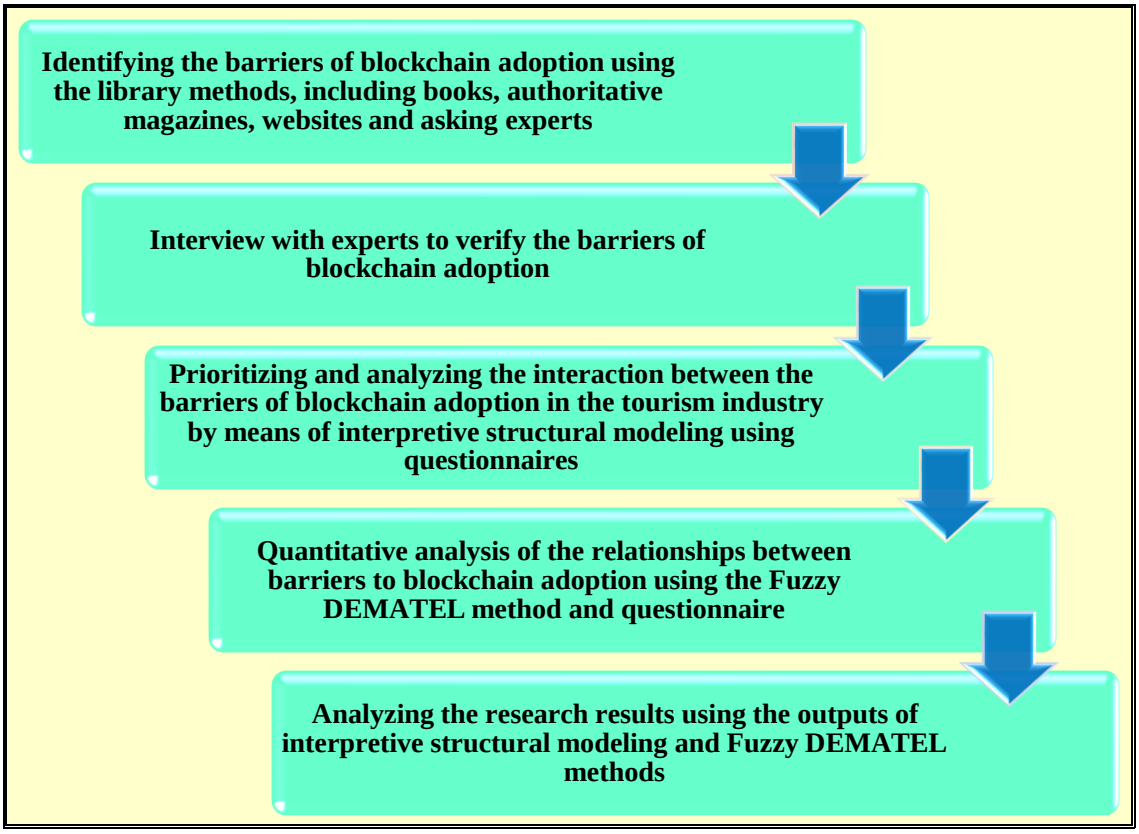

Figure 1

Research Process

In this research, the validity of the questionnaire was analyzed by content validity and face validity. The questionnaire's main variables were wholly extracted from the subject literature to determine the validity content. To increase the validity of the content, the barriers to Blockchain adoption were identified by reviewing the research literature, authoritative journals, and asking the experts opinions in the field of tourism. The questionnaire was evaluated by several experts, management professors, and experts to determine the face validity, and to confirm its validity, they was asked about the variables of the questionnaire. A re-test was used to determine the reliability of the questionnaire. For this purpose, questionnaires were distributed among specialists and experts over two periods. Experts reviewed the final list of barriers, and it was declared that no changes to the list were required. Moreover, the researcher ensured that the experts have sufficient knowledge and expertise regarding the research subject and the collected data are accurate enough.

4. Results

How to choose barriers to Blockchain adoption in the tourism industry was primarily explained in this section, and then, the interpretive structural modeling method was used to level the barriers. After stratification, the steps of performing fuzzy DEMATEL calculations were explained to extract the intensity of the effect of quantitative relationships between the barriers to Blockchain adoption.

4.1 Identification of Barriers to Blockchain Adoption

The data obtained from the research literature review and articles published in reputable journals were listed in Table 2 to identify the barriers to blockchain adoption in the tourism industry.

Table 2

Barriers to Blockchain Adoption Compiled from the Review of Texts and Articles

Researcher	Research title	Research area	Main barriers
Alketbi et al. (2018)	Blockchain for government services—Use cases, security benefits and challenges	government services	• Secure data sharing • Data integrity
Al-Saqaf & Seidler (2017)	Blockchain technology for social impact: Opportunities and challenges ahead	Areas under social influence	• Lack of standards • Interoperability
Atlam et al. (2018)	Blockchain with internet of things: Benefits, challenges, and future directions	The Internet of Things	• Scalability • Legal and compliance • Lack of adequate skills
Bag et al. (2021)	Barriers to adoption of Blockchain technology in green supply chain management	Green supply chain management	• Lack of management perspective • Cultural differences between supply chain partners
Biswas & Gupta (2019)	Analysis of barriers to implement Blockchain in industry and service sectors	Industry and service sectors	• Scalability • Sustainability costs
Boulos et al. (2018)	Geospatial Blockchain: Promises, challenges, and scenarios in health and healthcare	Health and healthcare	• Interoperability • Security and privacy
Erol et al. (2022)	Improving sustainability in the tourism industry through Blockchain technology: Challenges and opportunities	Tourism	• Lack of technical maturity • Lack of interoperability

Farooque et al. (2020)	Fuzzy DEMATEL analysis of barriers to Blockchain-based life cycle assessment in China	Manufacturing and retailing	• Immaturity of technology • Technical challenges for collecting supply chain data
Helliar et al. (2020)	Permissionless and permissioned Blockchain diffusion	permissionless and permissioned Blockchains	• Lack of knowledge • Changing regulations • Governance-appropriate regulation • Cost • Cooperation • Security and privacy • Lack of standardization • Legal Issues
Hosseini Bamakan et al. (2021)	Blockchain-enabled pharmaceutical cold chain: Applications, key challenges, and future trends	Pharmaceutical cold chain	• Data security and privacy • Storage capacity • Unspecified development cost • Standardization • Social challenges • Reciprocal performance • Cooperation
Kouhizadeh et al. (2021)	Blockchain technology and the sustainable supply chain: Theoretically exploring adoption barriers	Sustainable supply chain	• Technological and external barriers
Kwok & Koh (2019)	Is Blockchain technology a watershed for tourism development?	Tourism	• Market maturity • Political issues • Lack of regulations • Energy consumption
Mendling et al. (2018)	Blockchains for business process management - Challenges and opportunities	Business process management	• Throughput • Size and bandwidth • Limited usability • Security • Wasted resources
Rana et al. (2022)	Analysis of challenges for blockchain adoption within the indian public sector: An interpretive structural modelling approach	Public sector	• Lack of standards • Lack of validation • Security issues • Privacy concerns

Reyna et al. (2018)	On Blockchain and its integration with Internet of Things (IoT): Challenges and opportunities	Internet of Things	• Storage capacity and scalability • Security • Anonymity • Data privacy • Legal issues
Saheb & Mamaghani (2021)	Exploring the barriers and organizational values of Blockchain adoption in the banking industry	Banking	• Organizational and environmental barriers • Lack of understanding of senior managers • Compliance and legal requirements • Marketing noise
Sahebi et al. (2020)	Expert-oriented approach for analyzing the Blockchain adoption barriers in humanitarian supply chain	Humanitarian supply chain	• Regulatory uncertainty • Lack of staff knowledge training • High sustainability costs
Sanka et al. (2021)	A survey of breakthrough in Blockchain technology: Adoptions, applications, challenges and future research	Areas other than digital currencies	• Technical challenges • Legal challenges • Lack of understanding • Resistance to change
Sharma et al. (2021)	Technology assessment: Enabling Blockchain in hospitality and tourism sectors	Hospitality	• Lack of government regulation- in India • Market immaturity - in the Netherlands
Sydow et al. (2020)	Leveraging Blockchain's potential – The paradox of centrally legitimate, decentralized solutions to institutional challenges in Kenya	Public	• Sufficient technical capacity • Appropriate regulatory interventions • Accepting the logic of decentralization
Toufaily et al. (2021)	A framework of Blockchain technology adoption: An investigation of challenges and expected value	Public	• Technological immaturity • Environmental problems • Organizational issues
Yadav et al. (2020)	Blockchain technology adoption barriers in the Indian agricultural supply chain	Agricultural supply chain	• Lack of government regulations • Lack of trust among agricultural stakeholders
Yildizbasi (2021)	Blockchain and renewable energy: Integration challenges in circular economy era	Renewable energy	• High development costs • Non-acceptance by companies

Zhao et al. (2019)	Blockchain technology in agri-food value chain management: A synthesis of applications, challenges and future research directions	Agri-food value chain management	• Storage capacity • Scalability • Privacy leak • High cost • The problem of regulations • The issue of throughput and latency • Lack of skills
Zheng et al. (2017, 2018)	Blockchain challenges and opportunities: A survey	Public	• Scalability • Privacy leakage • Selfish mining
Zhou et al. (2020)	The key challenges and critical success factors of Blockchain implementation: Policy implications for Singapore's maritime industry	Maritime industry	• Implementation cost • Lack of experienced partners • Lack of data privacy

The 22 barriers identified from the articles listed in Table 2 were identified through interviews with experts; the list of barriers with their source is presented in Table 3.

Table 3

Blockchain Adoption Barriers Identified by Experts

Row	barriers	Reference
1	Immaturity of technology	Farooque et al. (2020), Kouhizadeh et al. (2021), Atlam et al. (2018), Biswas & Gupta (2019), Erol et al. (2022), Zheng et al. (2017, 2018), Zhao et al. (2019), Sydow et al. (2020), Toufaily et al. (2021), Mendling et al. (2018)
2	Technical challenges for data collection	Farooque et al. (2020), Sanka et al. (2021), Alketbi et al. (2018)
3	Challenges of cooperation, communication, and coordination	Hosseini Bamakan at al. (2021), Al-Saqaf and Seidler (2017), Tufaily et al. (2021), Saheb & Mamaghani (2021), Erol et al. (2022), Boulos et al. (2018), Helliar et al. (2020), Kouhizadeh et al. (2021)
4	Lack of knowledge, expertise and human capital	Helliar et al. (2020), Sahebi et al. (2020), Zhao et al. (2019), Atlam et al. (2018), Toufaily et al. (2021), Erol et al. (2022)
5	Lack of commitment and management support	Sharma et al. (2021), Toufaily et al. (2021), Kouhizadeh et al. (2021)
6	Lack of management perspective and understanding of senior managers	Bag et al. (2021), Toufaily et al. (2021), Saheb & Mamaghani (2021)
7	Security and privacy concerns	Boulos et al. (2018), Hosseini Bamakan at al. (2021), Mendling et al. (2018), Reyna et

		al. (2018), Zhao et al. (2019), Zheng et al. (2017, 2018), Zhou et al. (2020), Alketbi et al. (2018), Helliar et al. (2020), Kouhizadeh et al. (2021), Toufaily et al. (2021), (Rana et al., 2022)
8	Organizational issues	Saheb & Mamaghani (2021), Toufaily et al. (2021)
9	Lack of standardization	Hosseini Bamakan at al. (2021), Al-Saqaf & Seidler (2017), Helliar et al. (2020), Rana et al. (2022), Erol et al. (2022)
10	Compliance and legal requirements	Reyna et al. (2018), Atlam et al. (2018), Toufaily et al. (2021), Saheb & Mamaghani (2021)
11	Legal and contractual uncertainty	Reyna et al. (2018), Sanka et al. (2021), Helliar et al. (2020)
12	Lack of government regulations	Sharma et al. (2021), Yadav et al. (2020), Kwok & Koh (2019), Toufaily et al. (2021), Zhao et al. (2019)
13	Uncertainty of regulatory interventions	Sydow et al. (2020), Sahebi et al. (2020)
14	Lack of employee training and lack of customer awareness	Sahebi et al. (2020), Toufaily et al. (2021), Erol et al. (2022)
15	Storage capacity	Hosseini Bamakan et al. (2021), Reyna et al. (2018), Zhao et al. (2019)
16	Cultural differences among supply chain partners	Bag et al. (2021), Erol et al. (2022)
17	political issues	Kwok & Koh (2019)
18	Complexity and lack of understanding of the benefits of technology	Sanka et al. (2021), Toufaily et al. (2021), Erol et al. (2022)
19	Uncertainty and immaturity of the market	Kwok & Koh (2019), Saheb & Mamaghani (2021), Sharma et al. (2021)
20	Resistance to change and lack of acceptance by companies	Sanka et al. (2021), Sharma et al. (2021), Yildizbasi (2021), Toufaily et al. (2021)
21	Lack of experienced partners	Zhou et al. (2020)
22	High cost of implementation	Zhou et al. (2020), Toufaily et al. (2021), Biswas & Gupta (2019), Hosseini Bamakan et al. (2021), Sahebi et al. (2020), Yildizbasi (2021), Zhao et al. (2019), Erol et al. (2022)

Then, the barriers in the form of a questionnaire named "importance of barriers to acceptance" were given to the experts to express the importance of each of the barriers to acceptance on a Likert scale (1-5). The results of questionnaires in the Likert scale were entered into Statistical Package for the Social Sciences (SPSS) software to select the final barriers. Then, a one-sample t-test was performed with a mean of 3 (assumption one).

Table 4

The Average Table of Barriers to Acceptance

One-Sample Statistics				
	N	Mean	Std. Deviation	Std. Error Mean
Immaturity of technology	22	4.73	.456	.097
Technical challenges for data collection	22	2.50	1.144	.244

Challenges of cooperation, communication, and coordination	22	4.14	.710	.151
Lack of knowledge, expertise, and human capital	22	4.64	.492	.105
Lack of commitment and management support	22	3.82	.795	.169
Lack of management perspective and lack of understanding of senior managers	22	4.50	.740	.158
Security and privacy concerns	22	4.59	.666	.142
Organizational issues	22	2.55	1.143	.244
Lack of standardization	22	4.23	.752	.160
Compliance and legal requirements	22	2.64	1.049	.224
Legal and contractual uncertainty	22	2.59	1.141	.243
Lack of government regulations	22	4.45	.671	.143
Uncertainty of regulatory interventions	22	2.77	1.066	.227
Lack of employee training and customer awareness	22	4.18	.958	.204
Storage capacity	22	2.45	1.371	.292
Cultural differences among supply chain partners	22	4.18	.907	.193
political issues	22	2.86	1.283	.274
Complexity and lack of understanding of the benefits of technology	22	2.59	1.182	.252
Uncertainty and immaturity of the market	22	2.55	1.224	.261
Resistance to change and lack of acceptance by companies	22	3.77	1.066	.227
Lack of experienced partners	22	2.95	.899	.192
High cost of implementation	22	4.73	.456	.097

Table 5

One-Sample T-Test of Acceptance Barriers

One-Sample T-Test						
	Test Value = 3					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Immaturity of technology	17.773	21	.000	1.727	1.53	1.93
Technical challenges for data collection	-2.049	21	.053	-.500	-1.01	.01
Challenges of cooperation, communication, and coordination	7.505	21	.000	1.136	.82	1.45
Lack of knowledge, expertise, and human capital	15.588	21	.000	1.636	1.42	1.85
Lack of commitment and management support	4.827	21	.000	.818	.47	1.17
Lack of management perspective and lack of understanding of senior managers	9.507	21	.000	1.500	1.17	1.83

Security and privacy concerns	11.202	21	.000	1.591	1.30	1.89
Organizational issues	-1.865	21	.076	-.455	-.96	.05
Lack of standardization	7.659	21	.000	1.227	.89	1.56
Compliance and legal requirements	-1.627	21	.119	-.364	-.83	.10
Legal and contractual uncertainty	-1.682	21	.107	-.409	-.91	.10
Lack of government regulations	10.168	21	.000	1.455	1.16	1.75
Uncertainty of regulatory interventions	-1.000	21	.329	-.227	-.70	.25
Lack of employee training and lack of customer awareness	5.786	21	.000	1.182	.76	1.61
Storage capacity	-1.867	21	.076	-.545	-1.15	.06
Cultural differences among supply chain partners	6.112	21	.000	1.182	.78	1.58
political issues	-.498	21	.623	-.136	-.71	.43
Complexity and lack of understanding of the benefits of technology	-1.624	21	.119	-.409	-.93	.11
Uncertainty and immaturity of the market	-1.742	21	.096	-.455	-1.00	.09
Resistance to change and lack of acceptance by companies	3.400	21	.003	.773	.30	1.25
Lack of experienced partners	-.237	21	.815	-.045	-.44	.35
High cost of implementation	17.773	21	.000	1.727	1.53	1.93

According to the test results in Tables 4 and 5, eleven barriers, with a significance level of less than 0.05, were selected to reject the null hypothesis. The rest of the barriers were removed from the set. Eleven barriers to final acceptance are presented in Table 6.

Table 6

Final Acceptance Barriers

Row	barriers	Description
O1	Immaturity of technology	Blockchain is a nascent technology and has a long way to become mature. Therefore, the adopters are concerned with its technical immaturity and regulatory risks (Toufaily et al., 2021). Undeveloped technology may lack the necessary level of robustness in terms of data throughput, scalability, and latency, posing a serious problem in an interconnected ecosystem such as the tourism industry (Erol et al., 2022).
O2	Challenges of cooperation, communication, and coordination	Since Blockchain projects should contain government, developers, financial actors, start-ups, regulators, accountants, audit companies, and consultants, collaboration and coordination in the tourism industry are considered the main elements of effective Blockchain implementation (Erol et al., 2022).
O3	Lack of knowledge, expertise, and human capital	Knowledge related to business models, technical aspects, and governance of Blockchain technology is not only essential to better understand the technology per se but also for its implementation (Toufaily et al., 2021). Lack of adequate skills among the executives and employees to handle Blockchain technology would affect the way Blockchain has been planned to be implemented and used (Rana et al., 2022). The recent advancement and increasing sophistication of technology has amplified the gap between the demand for competent human resources and expertise and the supply of such personnel (Erol et al., 2022).

O4	Lack of commitment and management support	As the technology involves new regulations, acquisition and integration of new resources, and re-engineering of transactions and systems, top management support and vision play a crucial role in Blockchain adoption (Clohessy et al., 2019). The lack of commitment from top or middle management creates problems. Their support is essential for Blockchain technology implementation (Mangla et al., 2017).
O5	Security and privacy concerns	Given that Blockchain transactions are posted on the public database for review by anyone, this creates an environment that leads to privacy issues for this technology (Rana et al., 2022). There are concerns that data and information may be open to security concerns, such as hacking, inaccurate information dispersal, and access to sensitive information (Kouhizadeh et al., 2021).
O6	Lack of standardization	Lack of unified standards (e.g., terminology and concepts, security risks and vulnerabilities, overview of identity, reference architecture, taxonomy and ontology, legally binding smart contracts, etc.) impedes Blockchain technology to be properly implemented and used (Rana et al., 2022). Moreover, a lack of standard policies and frameworks for sustainability and lack of engagement prevents the advancement of integrated systems (Mangla et al., 2018).
O7	Lack of government regulations	Laws, regulations and appropriate governance frameworks related to the liabilities of respective parties, the applicability of law in case of disputes, decisions of authorized participants on the network, and mitigation of market manipulation and unfair practices should all be clarified to ensure Blockchain adoption (Janssen et al., 2020).
O8	Lack of employee training and lack of customer awareness	Because Blockchain technology is at the intersection of several disciplines, from cryptography and computer science to economics and game theory, even the basics are difficult to understand, both conceptually and technically (Swan, 2017). There needs to be more awareness, education and understanding about the benefits and applicability of Blockchain among the ecosystem stakeholders. As Blockchain is broadly understood and recognized, it would be easier to adopt (Toufaily et al., 2021).
O9	Cultural differences among supply chain partners	Adopting Blockchain technology changes or transforms current organizational culture. Organizational culture consists of guidelines of work culture and appropriate behavior through organizations (Kouhizadeh et al., 2021). Cultural and geographical differences between supply chain partners can hinder the implementation of Blockchain technology. These differences often hinder the adoption of tools and a uniform performance system throughout the supply chain (Sajjad et al., 2015).
O10	Resistance to change and non-acceptance by companies	Internal organizational changes for new standards would lead to difficulty in establishing connections via Blockchain between firms as the systems may vary in architecture (Kouhizadeh et al., 2021). In organizations, there is a lack of comprehensive Blockchain understanding, impeding its implementation (Mougayar, 2016). Individuals may associate Blockchain technology primarily with cryptocurrencies such as Bitcoin. These developments might be perceived as malicious activities. Therefore, organizations may hesitate adoption of general Blockchain technology (Swan, 2015). Adopting new systems would require altering or replacing legacy systems. This issue may cause resistance and hesitation from organizations and industries.
O11	High cost of implementation	New technology will be costly for the organization and the system partners. It also aids in supporting people and processing infrastructure (Mougayar, 2016). The cost to install, maintain and secure Blockchain has a negative impact on the implementation and the use of this technology (Rana et al., 2022).

4.2 Leveling of Barriers to Acceptance Using Interpretive Structural Modeling

After identifying the final acceptance barriers, the next step is to create contextual relationships between them. These textual connections are determined by a pair-by-pair comparison between the barriers and the answers obtained from the experts. Based on the pair-by-pair comparison, a structural autocorrelation matrix is constructed. Then, the transferability between the relationships is checked and converted into the reachability matrix using the numbers 0 and 1.

The first step was the formation of the self-interaction matrix, in which the two-by-two relationships of the variables were specified with the symbols (V, A, X, O). Experts completed this matrix through a questionnaire and the results are presented in Table 7.

Table 7

Structural Self-Interaction Matrix

Row	C11	C10	C9	C8	C7	C6	C5	C4	C3	C2	C1
O1	V	V	O	O	O	O	V	V	X	O	-
O2	O	X	A	A	A	A	A	A	A	-	
O3	V	V	O	V	O	O	V	V	-		
O4	A	X	A	O	A	A	A	-			
O5	O	V	O	A	A	A	-				
O6	O	V	O	O	A	-					
O7	O	V	O	V	-						
O8	O	X	O	-							
O9	O	V	-								
O10	A	-									
O11	-										

The initial reachability matrix was obtained in the next step by transforming the self-interaction structure matrix into a matrix with zero and one values. Then, the final reachability matrix was formed from the initial reachability matrix by inserting the transferability property in the criteria relations. In this matrix, the "influence power" column was obtained from the sum of the rows, indicating the influence of each barrier on other barriers. The "dependency" column was obtained from the sum of the barriers columns and indicates the effectiveness. The final reachability matrix is presented in Table 8. Finally, leveling was determined by four repetitions, presented in Table 9.

Table 8

The Final Reachability Matrix

Row	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	Penetration power
O1	1	1*	1	1	1	0	0	1*	0	1	1	8
O2	0	1	0	1*	0	0	0	1*	0	1	0	4
O3	1	1	1	1	1	0	0	1	0	1	1	8
O4	0	1	0	1	0	0	0	1*	0	1	0	4
O5	0	1	0	1	1	0	0	1*	0	1	0	5
O6	0	1	0	1	1	1	0	1*	0	1	0	6
O7	0	1	0	1	1	1	1	1	0	1	0	7
O8	0	1	0	1*	1	0	0	1	0	1	0	5

O9	0	1	0	1	0	0	0	1*	1	1	0	5
O10	0	1	0	1	1*	0	0	1	0	1	0	5
O11	0	1*	0	1	0	0	0	1*	0	1	1	5
dependency	2	11	2	11	7	2	1	11	1	11	3	

Table 9

Leveling of Barriers

Barriers	Reachability set	Antecedent set	Intersection set	Level
First iteration				
O1	1,2,3,4,5,8,10,11	1,3	1,3	
O2	2,4,8,10	1,2,3,4,5,6,7,8,9,10,11	2,4,8,10	1
O3	1,2,3,4,5,8,10,11	1,3	1,3	
O4	2,4,8	1,2,3,4,5,6,7,8,9,10,11	2,4,8	1
O5	2,4,5,6,8,10	1,3,5,6,7,8,10	5,6,7,8,10	
O6	2,4,5,6,8,10	6,7	6	
O7	2,4,5,6,7,8,10	7	7	
O8	2,4,5,6,8,10	1,2,3,4,5,6,7,8,9,10,11	2,4,5,6,8,10	1
O9	2,4,8,9,10	9	9	
O10	2,4,5,6,8,10	1,2,3,4,5,6,7,8,9,10,11	2,4,5,6,8,10	1
O11	2,4,8,10,11	1,3, 11	11	
Second iteration				
O1	1,3,5,11	1,3	1,3	
O3	1,3,5,11	1,3	1,3	
O5	5, 6	1,3, 5, 6,7,10	5,6	2
O6	5, 6	6,7	6	
O7	5, 6,7	7	7	
O9	9	9	9	2
O11	11	1,3,11	11	2
Third iteration				
O1	1,3	1,3	1,3	3
O3	1,3	1,3	1,3	3
O6	6	6,7	6	3
O7	6,7	7	7	
Fourth iteration				
O7	7	7	7	4

According to the levels specified in Table 9, "Challenges of cooperation, communication, and coordination" (2), "Lack of commitment and management support" (4), "Lack of employee

training and lack of customer awareness," and "Resistance to change and non-acceptance by companies" (10) are placed at level one, which is the highest level in the hierarchy of interpretive structural modeling. "Security and privacy concerns" (5), "cultural differences among supply chain partners" (9), and "resistance to change and non-acceptance by companies" (11) are placed at the second level. The third level, "Technological immaturity" (1), "lack of knowledge, expertise, and human capital" (3), and "lack of standardization" (6) are located. At the fourth level, representing the lowest level in the interpretive structural modeling hierarchy, is the "lack of government regulations" (7). After determining the level of the criteria, we connect the relationship between each pair with a directed arc; the direction of the arc indicates the existing relationship between the two elements. The hierarchical structure of the interpretive structural modeling is illustrated in Figure 2.

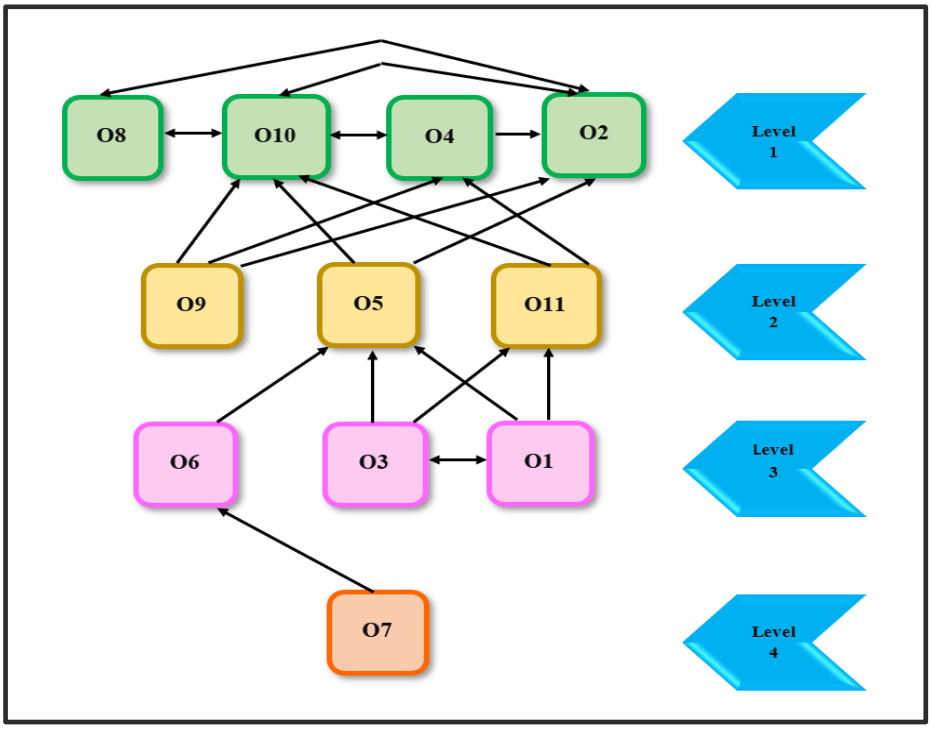

Figure 2

The Hierarchical Structure of Interpretive Structural Modeling

4.3 Determining the Intensity of Relationships Between Criteria Using the Fuzzy DEMATEL Method

At this stage, the DEMATEL-Fuzzy questionnaire was provided to the experts to determine the intensity of the relationships between the criteria in the form of a matrix. The experts were asked to determine the intensity of the relationship between barriers by linguistic scales, according to Table 1 in the methodology section. The results of the questionnaires, after the arithmetic mean, are listed in Table 10.

Table 10

The Couple Questionnaire of the Relationships Intensity Between Criteria

Row	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11
O1	NO	NO	NO	VL	L	NO	NO	NO	L	H	H

O2	L	NO	NO	L	L	H	NO	VL	L	H	NO
O3	H	L	NO	H	VH	H	L	H	L	VH	VH
O4	L	L	L	NO	H	NO	NO	L	NO	L	NO
O5	NO	H	NO	L	NO	L	NO	VL	NO	H	NO
O6	H	VL	NO	H	VH	NO	NO	NO	VL	VH	H
O7	L	L	NO	H	VH	H	NO	L	L	VH	NO
O8	H	VL	VH	H	H	L	NO	NO	L	VH	H
O9	L	H	NO	L	NO	NO	NO	L	NO	H	NO
O10	VH	H	H	H	NO	NO	NO	L	L	NO	NO
O11	VH	L	NO	L	NO	NO	NO	NO	VL	VH	NO

First, the normalized matrix and subsequently, the aggregated fuzzy collective relations matrix T were calculated. Finally, the DE fuzzy matrix, along with the values of the intensity of the total effect and the intensity of the net effect of the criteria, are presented in Table 11. The sum of the elements of each row (Di) and the sum of the elements of each column (Ri) are calculated from the matrix T, and columns D+R and D-R are obtained to determine cause and effect criteria.

Table 11

The Defuzzy Matrix, Cumulative Effect Intensity and Net Effect Intensity of Criteria

Row	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	D	R	D+R	D-R
O1	0.0504	0.0505	0.0285	0.0765	0.0858	0.0241	0.0101	0.0336	0.0852	0.1367	0.1038	0.6852	1.4193	2.1045	-0.7341
O2	0.1175	0.0539	0.0380	0.1163	0.1062	0.1118	0.0124	0.0673	0.0945	0.1531	0.0406	0.9116	1.1681	2.0797	-0.2565
O3	0.1863	0.1455	0.0573	0.1818	0.1858	0.1376	0.0744	0.1432	0.1235	0.2258	0.1617	1.6229	0.6755	2.2984	0.9474
O4	0.1121	0.1050	0.0880	0.0590	0.1301	0.0416	0.0149	0.0925	0.0443	0.1266	0.0412	0.8553	1.3725	2.2278	-0.5172

-0.4567	0.2708	1.0285	0.574	-0.108	-0.7091	-0.0391	O5
1.9205	1.8022	1.4445	2.248	1.6636	2.8115	1.5515	0.0596	0.1488	0.1359	0.1746	0.1109	0.1695	0.1537
1.1886	0.7657	0.208	0.837	0.8858	1.7603	0.7953	0.1238	0.0919	0.1267	0.1117	0.1247	0.1363	0.0981
0.7319	1.0365	1.2365	1.411	0.7778	1.0512	0.7562	0.0339	0.0404	0.0510	0.1495	0.0377	0.1186	0.0326
0.0307	0.1163	0.0503	0.1382	0.0341	0.0520	0.0264	0.1066	0.1451	0.1600	0.1693	0.1076	0.1465	0.1038
0.1396	0.1805	0.1957	0.2099	0.1429	0.0900	0.1595	0.0431	0.1512	0.1683	0.1555	0.0493	0.0698	0.0435
0.0380	0.0723	0.1069	0.1151	0.0367	0.1036	0.0657	0.0847	0.0307	0.1254	0.1045	0.0333	0.0456	0.0264
0.0612	0.0463	0.1060	0.0602	0.0893	0.1013	0.0361	0.0107	0.0130	0.0103	0.0225	0.0113	0.0180	0.0104

The cause-and-effect diagram in Figure 3 was drawn using the total effect and net effect values. The sum of the elements of each line (D) indicates the impact of that barrier on other system barriers. Therefore, the "lack of training of employees and lack of awareness of customers" is the most effective barrier. The sum of the elements of the column (R) for each barrier indicates the degree of influence of that barrier on other barriers of the system. Therefore, "resistance to change and non-acceptance by companies" has a very high level of effectiveness. The horizontal vector (D+R) represents the degree of influence and the impression of the barrier in the system. In other words, the higher the D+R value of a barrier, the greater the barrier's interaction with other system factors. Therefore, "resistance to change and non-acceptance by companies" interact most with the other studied barriers. The vertical vector (D-R) indicates the strength of the barrier. In general, if D-R is positive, the variable is considered a "cause" barrier, while if it is negative, it is considered "effect." In this research, "lack of government regulations," "lack of employee training and lack of customer awareness," "lack of standardization," and "lack of knowledge, expertise, and human capital" are the "cause" variables. However, "Security and privacy concerns," "Lack of commitment and management support," "Resistance to change and non-acceptance by companies," "Cultural differences among supply chain partners," "Challenges of cooperation, communication, and coordination," "technological immaturity," and "high implementation cost" are "effect" variables.

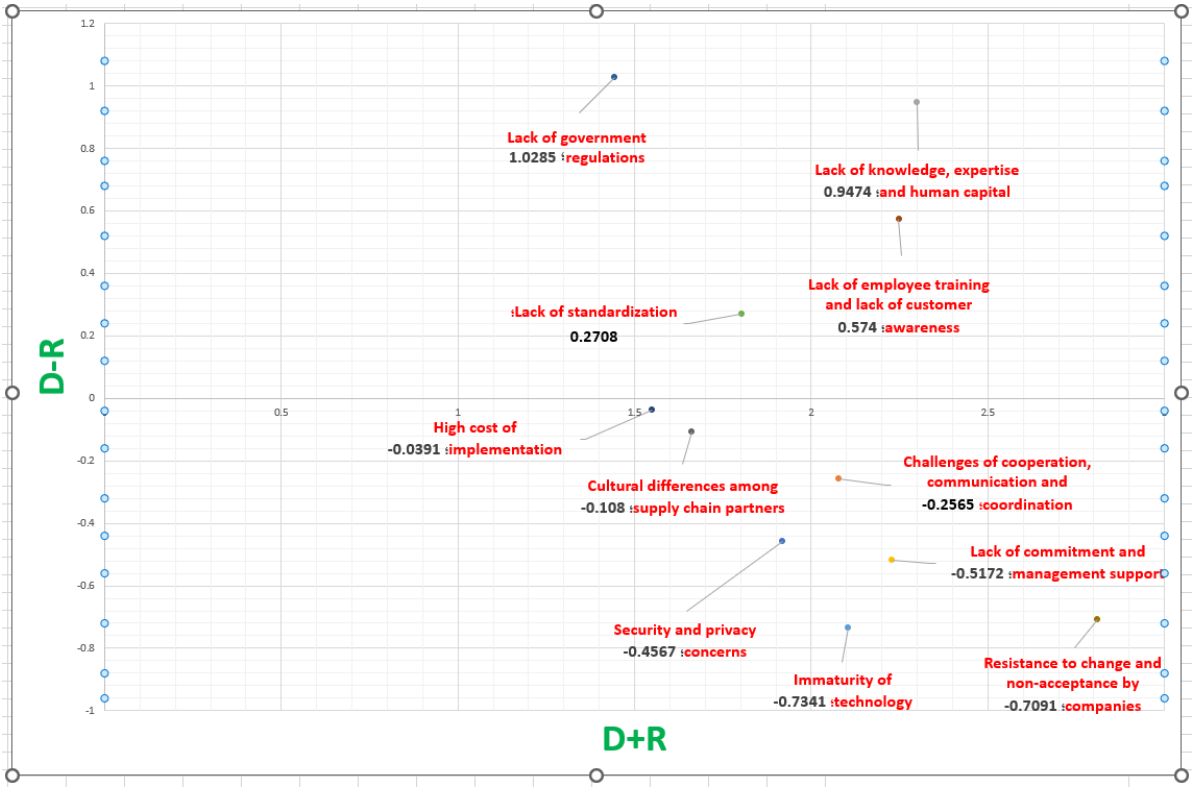

Figure 3

Cause and Effect Diagram

5. Discussion

The main goal of this research was to identify the barriers to blockchain adoption in the tourism industry, and in the findings section, eleven final adoption barriers were identified. Identifying barriers, determining the level, and analyzing the relationships between barriers are vital for the progress of this field. Therefore, it is expected that the findings of this research will provide a deeper insight into the potential and supportive role of blockchain to policymakers and practitioners, as well as guidelines to overcome the barriers of blockchain adoption in tourism. However, to increase the adoption level of blockchain in the tourism industry, more studies are needed to analyze and improve the knowledge in the field of blockchain. Based on the leveling and hierarchical model of ISM, the following propositions were concluded, which include the most influential barriers to blockchain adoption in the tourism industry:

1. "Technological immaturity" in blockchain leads to "high implementation cost," "security and privacy concerns," and "lack of knowledge, expertise, and human capital" in the tourism industry.

2. "Lack of knowledge, expertise, and human capital" in the field of blockchain leads to "technological immaturity," "high implementation cost," and "security and privacy concerns" in the tourism industry.

3. "Lack of government regulation" related to blockchain technology leads to a "lack of standardization" in the tourism industry.

4. "Lack of standardization" associated with blockchain technology leads to "security and privacy concerns" for tourism industry users.

Based on DEMATEL's examination of the relationships between barriers and cause-and-effect relationships, the following statements were concluded from the relationships between barriers to blockchain adoption in the tourism industry:

1. "Resistance to change and non-acceptance by companies" had the most interactions with other barriers examined.

2. "Lack of government regulation" had the slightest interaction with other barriers under investigation.

3. "Lack of government regulations," "Lack of employee training and lack of customer awareness," "Lack of standardization," and "Lack of knowledge, expertise, and human capital" are the influencing or cause variables.

4. "Security and privacy concerns," "Lack of management commitment and support," "Resistance to change and non-acceptance by companies," "Cultural differences among supply chain partners," "Challenges of cooperation, communication, and coordination," "technological immaturity," and "high implementation cost" are affected or disabled.

The results of this study were consistent with the results of several studies. Errol (2022) states that "technical immaturity" and "lack of interoperability" are the most critical challenges of blockchain in the tourism industry. The Kouhizadeh et al.'s (2021) study also highlights that supply chain and technological barriers are the most critical among academics and industry experts. Sharma et al. (2021) stated that "Lack of government regulations/policy" and "Market uncertainty" are the most critical barriers to adoption in the hospitality and tourism industry. The results of the study by Rana et al. (2022) show that the most important barrier in the hierarchical structure of blockchain adoption, i.e., its lowest level, is the "lack of standards" and "lack of validation."

5.1 Theoretical Concepts

The present study has used mixed research, including qualitative research with MCDM techniques (Fuzzy DEMATEL) and quantitative research using the ISM method to provide a general structure of the effectiveness of barriers to acceptance and the hierarchical relationship between them. This combination was necessary to address the research questions, i.e., identifying, prioritizing, and investigating the causal relationships between barriers. The study results provide a framework for decision-making so tourism stakeholders can make decisions and take action to overcome barriers.

5.2 Practical Concepts

This part of the present study provides management implications for tourism and hospitality companies, government policymakers, and blockchain technology service organizations. The results of the analysis of barriers to the adoption of blockchain in the tourism industry provide industry managers, decision-makers, and policymakers with information to organize programs to overcome the related barriers.

The first result of this study was the identification of barriers to the adoption of blockchain technology in tourism. This was done by reviewing research literature and articles published in reputable journals and surveying experts. Twenty-two barriers were selected through interview sessions with twenty-two technology and tourism experts. Then, eleven barriers were identified using a questionnaire completed by experts and through a one-sample t-test. These barriers include technological immaturity, collaboration, communication, and coordination challenges, lack of knowledge, expertise, human capital, management commitment, and support, security and privacy concerns, non-standardization, lack of government regulations, lack of employee training, and lack of customer awareness, cultural differences between supply chain partners, resistance to change and non-acceptance by companies, and high cost of implementation. The

current study provides a list of barriers to blockchain adoption in the tourism industry that will be valuable for companies and managers to know and help them focus on overcoming the barriers in their organization. The second result of this study was to identify the critical barriers to the adoption of blockchain in terms of power of influence in the tourism industry. The interpretive structural modeling method was used to determine the level of barriers and prioritize them based on the "power of penetration." The barriers of "technological immaturity," "lack of knowledge, expertise, and human capital," "lack of government regulations," and "lack of standardization" were identified as the most effective barriers. The barriers of "high implementation cost," "security and privacy concerns," and "cultural differences between supply chain partners" had moderate effectiveness. Finally, the barriers "Challenges of cooperation, communication, and coordination," "Lack of commitment and management support," "Resistance to change and non-acceptance by companies," and "Lack of employee training and lack of customer awareness" were identified as the most effective or dependent barriers.

The third result of this research was to determine the relationship between each of these barriers. In this research, the fuzzy DIMETAL method drew the diagram of mutual influence and the intensity of influence between barriers. The barrier "resistance to change and non-acceptance by companies" had the most interaction, while the "lack of government regulations" had the slightest interaction with the other barriers examined. The "Lack of government regulations," "lack of training of employees and lack of customer awareness," "lack of standardization," and "lack of knowledge, expertise, and human capital" are influencing or cause variables. "Security and privacy concerns," "Lack of commitment and management support," "Resistance to change and non-acceptance by companies," "Cultural differences among supply chain partners," "Challenges of cooperation, communication, and coordination," "technological immaturity," and "high implementation cost" are the affected or disabled barriers.

Further studies, an analysis of technology potential, the improvement of technology maturity, and blockchain interoperability are required to enhance the adoption level of blockchain in the tourism industry. The public sector should ensure awareness and skills training programs for employees to embrace this emerging technology. Fragni`ere et al. (2022) argued that governments should adopt measures to support the growth of blockchain in the tourism industry. In particular, governments can support national research institutes and tourism ministries through funding projects focusing on improving the effectiveness of blockchain in terms of indicators such as throughput, scalability, trust, privacy, and interoperability. Governments can also participate in the early stages of blockchain implementation by encouraging innovation and investment in blockchain through flexible regulations and policies. Through government support, businesses may assess markets for new blockchain solutions within regulatory frameworks for user safety (Ølnes et al., 2017). Until governments are convinced that blockchain is technologically mature and interoperable, support and incentives for its implementation may be considered insufficient by the tourism industry (Erol et al., 2022).

The lack of integration of blockchain technology and high levels of resistance among public sector employees affect the adoption of this technology. Management needs to develop resistance reduction strategies and policies to eliminate employee resistance to ensure the successful deployment of ultra-modern, transparent, secure, and fast systems that can address more complex problems (Rana et al., 2022). Defining the value proposition of blockchain technology for a supply chain reduces the "lack of commitment and high-level management support" (Kouhizadeh et al., 2021). Supply chain barriers and coordination and communication challenges can be reduced by developing corporate cultures toward a collaborative ecosystem for technology advancement. Finding the right partners to build effective governance structures

(Korpela et al., 2017) is essential for successful blockchain adoption. "Problems in collaboration, communication, and coordination" and "issues of security, privacy, and monitoring" arise due to a lack of trust, fear of unrestricted access to data, technical limitations, and chances of more accessible access to essential data (Farooque et al., 2020). Another critical barrier is "resistance to change," which is very common when a company or group of users tries to adopt new technologies. There are many reasons to oppose emerging technologies, including a fear of lack of trust and unwillingness to learn new techniques. This can be overcome by having campaigns highlighting technology's positive aspects and benefits. Moreover, consumers must be assured that all their electronic transactions are safer, more complete, and more secure, encouraging them to switch to blockchain or at least try it (Sharma et al., 2020). The findings of this study provide suggestions for industry professionals, researchers, and tourism industry managers to adopt the strategy of their respective organizations. Regarding the barrier "lack of training of employees and lack of awareness of customers," the government should ensure that public sector and tourism institutions receive adequate training and understanding of the technology being implemented and used in their organization. Despite the low cost and high security of sending payments over the network on the blockchain, a "lack of standardization" can negate these benefits. Therefore, government agencies should ensure improved standardization and validation in the existing blockchain infrastructure to optimize its effective implementation cost, security, and privacy. To overcome "resistance to change and non-acceptance by companies," the government and tourism organizations should provide training programs for employees and managers regarding the benefits and applications of blockchain. These programs can encourage acceptance of this emerging technology and reduce resistance to technology adoption. "Lack of government regulations" is another critical barrier that needs to be addressed. Governments should enact laws facilitating blockchain implementation in potential businesses and travel agencies in different regions. Considering the high impact of the "lack of knowledge, expertise, and human capital" on other barriers, efforts should be made to overcome this barrier by providing specialized training in blockchain in tourism education institutions and universities.

6. Conclusion

Despite its potential applications and benefits, blockchain implementation and development, such as other technologies, has many challenges. Therefore, to effectively use blockchain, its challenges and barriers must be carefully identified to minimize their adverse effects. Researchers in the field of tourism should analyze and investigate the barriers identified in the adoption of blockchain so that the legislators can overcome the barriers to the implementation of blockchain. Moreover, policymakers in the field of tourism can explain the policies and strategies of this field employing these studies. This study identified barriers to adopting blockchain technology in the tourism industry. Eleven barriers were selected from the literature, and the ISM-DEMATEL method was used to establish mutual relationships between them and place them in the causal, effectual, and dependent barriers categories. Findings indicated that "technological immaturity" and "lack of government regulation" are critical barriers to blockchain adoption in the tourism industry. "Lack of government regulations," "lack of training of employees and lack of customer awareness," "lack of standardization," and "lack of knowledge, expertise, and human capital" are influential variables. "Security and privacy concerns," "Lack of commitment and managerial support," "Resistance to change and lack of acceptance by companies," "Cultural differences between supply chain partners," "Challenges of cooperation, communication, and coordination," "technology immaturity" and "high implementation cost" are influential variables. The results obtained from the ISM approach provide a valuable understanding of the hierarchy and relationships between barriers.

Furthermore, the use of the DEMATEL approach determines the quantitative prioritization of the barriers and the intensity of the relationships between them. These results help practitioners and policymakers in this sector in knowing how to minimize these barriers to ensure blockchain adoption. In addition, the decisions and prioritization to overcome the barriers to adopting this technology differ. Findings can facilitate the decision-making process for policymakers and policy planners involved in this process. The primary significant result of this exploratory study is that we examined barriers through causality and salience. The results of our study allow organizations to prioritize their efforts and actions to manage time and resources. In addition, the hierarchies and relationships examined between drivers and barriers using the views and perceptions of the industry and academic experts, respectively, categorized them at different levels, dividing them to cause-and-effect groups.

The contributions of this study are as follows: First, this study has exclusively identified and analyzed the barriers to blockchain adoption in the tourism industry by reviewing and compiling relevant literature in this field and expert opinions. Second, this study has determined the priority and relationship between barriers using the ISM-DEMATEL approach. The results show how some barriers to blockchain adoption are related to other barriers, providing valuable information and functional categories for industry stakeholders and blockchain professionals. These categories provide a better understanding of adoption barriers, namely "influence and influence" or "influence and dependency" characteristics, when developing and implementing emerging blockchain technology. Third, the managerial and policy implications of our findings were also discussed.

This research has limitations that should be considered by researchers in the future. First, this study is based on data collected from a small number of professionals in the tourism industry. Increasing the number of experts will be beneficial in generalizing the research results. Second, as blockchain is an emerging field and its aspects are not yet fully known, this research may have limitations from a technical and operational point of view. Third, this study examines only twenty-six articles in exploratory literature and scientific databases for data collection.

Similar studies should be conducted in sectors other than the tourism industry, where blockchain adoption has taken place and determined how that industry has overcome the challenges involved. This practice may offer significant benefits in facilitating the adoption of blockchain technology in the tourism industry. In addition, it is suggested that researchers use the AHP approach to rank barriers so that the weight of each can be obtained along with the leveled graph of acceptance barriers. It is also suggested that the models presented in this research, which have yet to be analyzed statistically, should be implemented through the structural equation modeling method.

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