INTERNATIONAL JOURNAL OF MARITIME TECHNOLOGY

IJMT Vol.18/Spring & Summer 2023 (40-51)

Available online at: www. ijmt.ir

Studying the Impact of Blockchain Technology on Maritime Trade with Focusing on Identifying and Prioritizing the Underlying Factors for its Adoption in Iran's Maritime Trade

Mehran SabzGashtasebi[1*], Homayoun Yousefi[2], Mohammad Amin Kouhbor[3]

[1] *M.Sc. Faculty of Economics and Management, Khorramshahr University of Marine Science and Technology, Khorramshahr, Iran Msh.Sgpi@gmail.com*

[2] *Associate Professor, Khorramshahr University of Marine Science and Technology - Khorramshahr, Iran homayounyousefi@yahoo.com*

[3] *Assistance Professor, Khorramshahr University of Marine Science and Technology - Khorramshahr, Iran aminkuhbor@yahoo.com*

ARTICLE INFO

Article History:
Received: 27 Feb 2022
Accepted: 16 Oct 2023

Keywords:
Blockchain, disruptive technology, maritime trade, paperless trade, distributed ledger

ABSTRACT

Blockchain is a novel and disruptive technology that has the potential to transform the current international business and trade processes that rely on traditional intermediaries. It is a distributed ledger that verifies and records transactions using a peer-to-peer network over time in a sequence of blocks, secured by cryptographic functions that are complex, immutable and tamper-proof. International maritime trade, which is the main mode of global transportation, expects to change its business model by adopting blockchain, which enables a decentralized architecture of international transactions without intermediaries and facilitates paperless trade. Moreover, blockchain aims to address the problems and inefficiencies that plague maritime trade. However, there are key factors that influence the adoption of blockchain in maritime trade that need to be investigated in order to successfully implement this technology in the future. This study examined the impact of blockchain technology on maritime trade and identified the factors affecting its acceptance in Iranian maritime trade using the research background, literature review and interviews with experts who were PMO managers. These factors were validated by the Delphi method and then categorized and prioritized using the theoretical framework of technology, organization, environment (TOE) and analytical hierarchy process. The results indicated that "blockchain benefits" in the "technology" dimension, "human resource capability" in the "organization" dimension and "government support and policy" in the "environment" dimension were ranked first. These findings could assist the stakeholders in Iran's maritime trade, such as ports, customs, government agencies, and transportation logistics companies, in developing strategies for the successful adoption and advancement of blockchain and enhancing their organizational competitiveness.

1. Introduction

Technological innovations have always been a driving force for the development of the world economy and trade. For instance, the steam engine, electricity, and the Internet have transformed the production and distribution of goods and services across the globe. However, one aspect of global trade that has remained largely unchanged is the use of paper documents for transactions and business interactions, especially in maritime trade. Maritime trade involves multiple actors and processes that require a high level of coordination and trust, which are often hampered by the inefficiencies and delays of paper-based documentation. Moreover, new challenges such as the COVID-19 pandemic have exposed the vulnerability of the current system and the need for more resilient and agile solutions. Blockchain technology is a promising innovation that can address these issues by enabling digitalization, transparency, and security of maritime trade transactions. Blockchain technology has various capabilities that can modernize international trade, but it also faces some barriers to its adoption and implementation in the maritime sector. This paper aims to explore the potential benefits and challenges of blockchain technology for maritime trade and provide some recommendations for its future development.

The digitalization of economic activities is accelerating rapidly, with digital trade accounting for 22.5% of the world's GDP in 2015 and projected to reach 25.5% in 2022 [1]. According to a report by the World Economic Forum, removing barriers to digital trade could increase GDP by 5% and world trade by 15% [2]. However, there are still many obstacles that hinder the efficiency and effectiveness of global maritime trade and logistics, such as: port and customs management, ship turnaround time, document processing time, paperwork complexity, import and export procedures, document transparency, and software, technology, and infrastructure issues. A study by IBM and Maersk revealed that a shipment of roses and avocados from Kenya to Rotterdam involved more than 30 organizations, more than 100 individuals, more than 200 interactions, and a stack of paper documents with a diameter of 25cm [3]. The shipment took 34 days to arrive at its destination, out of which 10 days were spent on document processing. Furthermore, one of the key documents was lost and later found among a pile of papers. The cost of paper documents and processing accounted for approximately 15% of the total shipping cost, which was $2000. By fully digitizing the maritime supply chain, the world's largest shipping companies can save about $ 38 billion a year [4]. Maritime trade involves a large amount of paperwork and documentation, such as sales agreements, bill of lading, charter parties, customs clearance documents, credentials, etc. These documents have to go through multiple process chains for signing and approval. This makes the whole process prone to human error, fraud and unintended delays [5]. Moreover, other challenges such as security issues, lack of transparency, document forgery, data inconsistency among various domestic and international organizations and cyber-attacks have affected the global maritime trade and logistics and hindered the maritime trade from utilizing its full potential. According to the Iranian Ports and Maritime Organization in February 2021, 80% of the 4,900 ports around the world still rely on outdated and manual processes to manage maritime services. A new survey of more than 400 supply chain organizations from 64 different countries reveals that 69% of them do not have full transparency in their supply chain, 65% of them have experienced a major problem at least once and 41% of them still need a lot of paper documents and Excel Spreadsheet to track supply chain issues [6]. Modern maritime supply chains are complex and consist of diverse and multi-layered elements that compete individually in different locations to serve customers [7,8]. Statistics from the World Trade Organization indicate that 80% of the world trade volume and more than 70% of the world trade in terms of value are done through maritime transport in the world's ports. Also, the volume of international exports in 2019 in terms of value was approximately $19 trillion and the share of maritime transport was $14 trillion. According to the UNCTAD, 11 billion tons of goods were transported by sea in 2019, which is expected to increase by more than 3.5% annually in 2024 to 14 billion tons. Likewise, transportation and logistics costs will increase by the same amount, and consequently the problems of the maritime trade supply chain will become more evident. Therefore, blockchain technology is gradually entering the international maritime and logistics trade to enable digitization, which would facilitate faster tracking of goods, increased transparency, and reduced cost and time of customs clearance and ships turnover time.

2.Theoretical Foundations

Blockchain technology emerged in the cryptographic community in 2008 and was attributed to a person or group named Satoshi Nakamoto, whose identity remains unknown. It was first implemented in 2009 as the underlying cryptographic infrastructure of Bitcoin. Blockchain and Bitcoin are often conflated, but they are essentially distinct concepts. Blockchain is a technology that enables the Bitcoin platform and functions as a virtual Bitcoin infrastructure, while Bitcoin is a cryptocurrency. This confusion may have delayed the recognition of blockchain's potential applications beyond cryptocurrencies. The 2008 recession facilitated the operation, growth and development of cryptocurrencies, especially Bitcoin [9], as people lost trust in governments and the monetary and banking system and sought an alternative to a centralized and regulated financial system. In his white paper, Satoshi Nakamoto presented Bitcoin as a new model of privacy, using encryption rather than banks to verify transactions [10]. A blockchain is a record of transactions or a decentralized and distributed ledger, which means that it is not controlled by any single person, group or entity, unlike the conventional financial system that dominates the world. Blockchain is also distributed simultaneously, meaning that all events are shared among all participants and secured by complex mathematical cryptography. Blockchain is managed by computers or servers called "nodes" on a peer-to-peer network and operates without the need for intermediaries to validate transactions, such as banks.

The data entered into the blockchain are shared among all participants and validated by anyone with the necessary permissions, which is done through the consensus protocol. Once the data are validated, they are stored in blocks that are later linked together in chronological order by cryptographic techniques. In blockchain, each person has a complete copy of the blockchain data, and updates are shared with all participants at the same time. Therefore, blockchain participants all have access to the same information at any time. In simpler terms, a blockchain is a trusted shared ledger or a “trust machine”, which allows people who do not have special trust in each other to interact without trusted intermediaries such as banks. Because data are shared among many nodes in the blockchain network, it is almost impossible to forge transactions.

2.1 Blockchain features

2.1.1 Smart contracts

Blockchain technology offers a remarkable feature for international trade, namely smart contracts. The concept of smart contracts was first introduced in the field of blockchain technology in 2015 by ethereum. The term smart contracts may be misleading, as it does not involve any artificial intelligence components [11]. Smart contracts are essentially conventional contracts that are coded in computer language. They are executed automatically without the need for an intermediary once the preconditions for a contract are fulfilled. They rely on the computer logic of “if and then”. For instance, if the goods are loaded at port X, then the money is transferred. Unlike ordinary paper contracts, they can incorporate various parameters and variables that are recorded as input. Such information feeds that are recorded in smart contracts are called oracles. Oracles can be variables such as temperature, financial payments, price fluctuations, and so on. For example, in an insurance contract, a thermal sensor in a refrigerated container can act as an oracle, so that if the temperature rises above a certain level, insurance payments will be triggered automatically. This is why smart contracts often work well with the Internet of Things. Oracles are blockchain’s interface with the external world.

2.1.2 Immutability

Blockchain ensures the immutability of the information recorded in its blocks by using sophisticated cryptographic authentication algorithms. Blockchain employs hashing algorithms to create immutability. Cryptographic hashing functions have a property called “avalanche effect”, which means that the slightest change in input will have a very large impact on the hash. A chain of blocks also implies that any alteration in a block will change the hash stored in the previous blocks, resulting in a modification of the entire blockchain, which is virtually impossible.

2.1.3 Risk reduction

Blockchains can have a significant role in mitigating risks in the maritime supply chain. For instance, they can facilitate faster and more efficient business relationships and reduce transaction costs and risks. Also, blockchain eliminates the previous problems of transactions such as double spending, because only one transaction can be linked to the previous and next block.

2.1.4 Security

Blockchain enables every interaction, such as updates and shares, to be done with high speed and security. Using a hashing system and a distributed database can protect against hacking attacks. It is very difficult for hackers to penetrate the blockchain because altering a transaction will change the hash, and this is not consistent with the previously stored hashes.

2.1.5 Decentralization

Distributed databases like blockchain are actually a sharing platform without intermediaries. In a blockchain-based system in maritime trade where protocols such as smart contracts are executed automatically, there is no need for intermediaries such as freight forwarders, customs brokers and insurance companies. Because this system is decentralized, customers only interact with an integrated system, which is a great advantage.

2.1.6 Timestamping

Timestamping enables blockchain to record the time for all transactions. When a node verifies a transaction, it also checks the time with the time of the previous transactions, so there is no problem with double spending. Moreover, the timestamp, like a link, connects the blocks together. The timestamp sorts the stored data in a chronological order, which ultimately creates a chain of transactions.

2.2 Toward a paperless trade

International maritime trade involves multiple actors and operators and relies heavily on paper-based processes. In the field of maritime trade, numerous documents have to be processed, which can be categorized into four sections:

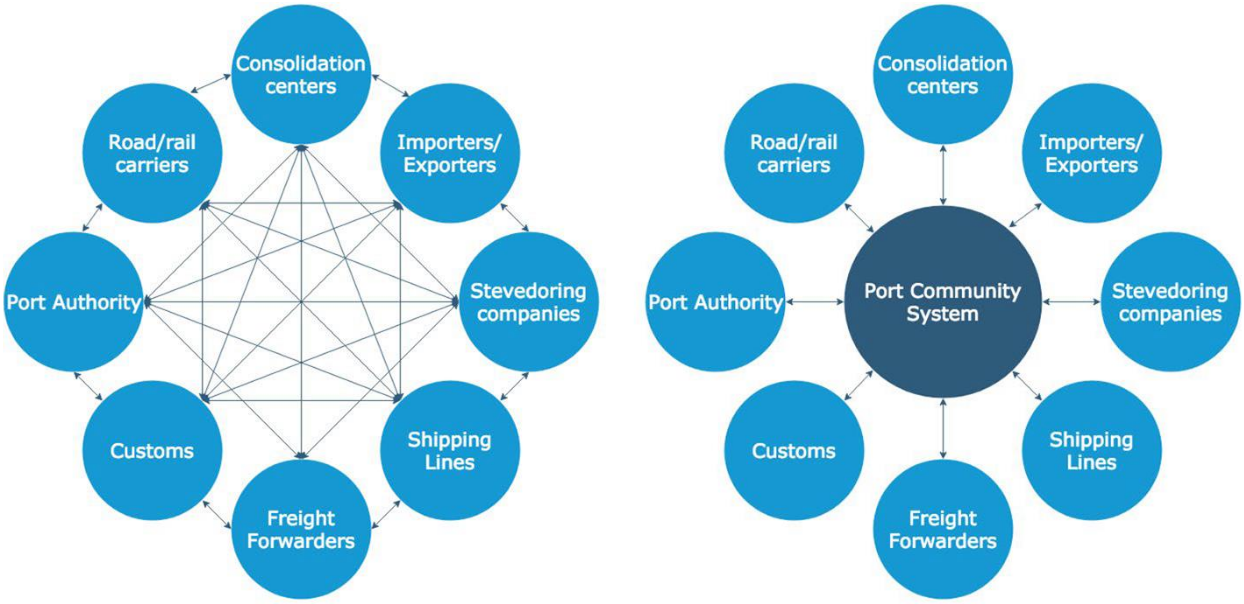


Figure 1. Schematic view of fragmented port community system and peer-to-peer system

1.Documents related to commercial transactions, such as sales contracts, commercial invoices, and product details
2.Documents related to financing, such as letter of credit, etc
3.Shipping documents, such as bill of lading
4.Documents related to border activities, such as certificate of origin, conformity certificate, import and export licenses, customs clearance letters and customs inspections These paper-intensive processes not only increase management and coordination costs, but also expose them to risks such as human error, forgery, and loss.

2.3 Blockchain in maritime trade

Maritime trade is currently a highly fragmented network in which different actors and groups collaborate for a single shipment (Figure 1). In such a fragmented business, interactions and transactions between institutions and operators can take various forms. Although the EDI system has been used in ports in recent years, transactions are still not generally digitalized, and companies and organizations still prefer to use traditional methods of doing business in maritime trade. It is well known that the use of traditional methods in shipping and maritime trade leads to high costs and inefficiencies. At present, most of the transactions and interactions in maritime trade are done traditionally and manually by phone and email and not through the EDI system. Each operator and organization in maritime trade has its own management system and platform, and inter-organizational interaction is usually not integrated in their systems. Lack of transparency is another major challenge of the maritime supply chain, and when cargo moves between organizations, no one can trace it. Also, the absence of a reliable intermediary often leads to price conflicts and inconsistencies. In fact, the World Economic Forum has estimated that fraudulent activities increase the cost of doing business by up to 10%. Another major problem with maritime trade inefficiencies is the inconsistency of data and information and the lack of transparency, which leads to problems such as repeatedly carrying empty containers, human errors, changing schedules, and increasing fines. With the adoption and integration of blockchain, all the steps and information sharing will be done very quickly and sometimes automatically, and all institutions have the ability to participate in it. For example, shipment information can be stored on a blockchain instead of on paper documents. This information will be available on an instantaneous basis at no additional cost, and institutions that were previously out of the cycle, such as banks and insurance companies, can be added to the cycle to speed up the process. Since 2017, the use of blockchain in maritime trade has been gradually increasing. These applications are usually divided into four categories:

1. Electronic bill of lading
2. Shipping operations
3. Ship financing
4. Ship insurance

2.3.1 Electronic bill of lading

The physical delivery of the bill of lading and its lengthy and time-consuming processing often cause delays [12]. Although many attempts have been made to create an electronic bill of lading, such bill of lading faces challenges such as fraud and confidentiality [13], which rely on a central system. Blockchain can greatly reduce these risks through peer-to-peer communication without any central intermediaries, and it can also enhance the confidentiality through solving complex mathematical cryptography and allowing only authorized people to decrypt it. In this way, the owner of the goods can digitally sign his electronic bill of lading and add the public key of the next owner in the blockchain transactions, which saves a considerable amount of time. Also, the ownership history can be preserved.

2.3.2 Shipping operation

Shipping operation processes are currently very outdated. A single transaction can involve numerous documents, such as sales agreements, bill of lading, charter parties, customs clearance documents, and letters of credit. Traditionally, maritime trade has depended heavily on the physical transmission of paper documents and the whole process can be vulnerable to human errors, frauds and unwanted delays. Blockchain can address this in several ways. First, blockchain can make the whole process paperless so that document information is immutable. Participants can use public and private keys to communicate with each other, transfer documents, and make payments and transactions. Second, the blockchain provides complete transparency in the trade and information on the blockchain can be viewed by participants. Third, by adopting smart contracts, standard shipping contracts can be replaced digitally on the blockchain, and the parties will have the freedom to negotiate financially directly on the blockchain. Numerous studies to date have emphasized the importance of information sharing to increase supply chain integrity and overall efficiency. If information is shared effectively in maritime trade, shipping costs could be reduced by $300 per container [14]. Sharing the capacity of containers also can save 6 billion per year and produce 4.5 million tons less carbon dioxide per year. One of the main logistical challenges in maritime trade is to monitor the quality of goods and their physical tracking to the destination [15,16]. At present, information systems are not able to provide instant information to goods during transport operations [17] . This leaves room for frauds that can cause a lot of financial loss for companies. Blockchain can improve the tracking problem by providing movement information for goods that are up-to-date and tamper-proof. This information will be available from the origin to the destination of the goods. Each product is assigned a unique ID and is scanned at each stage of shipping. This scanned data is stored in a blockchain through a chain of transactions and will be accessible to anyone. In addition, other information such as product temperature and container emptiness information can also be added.

2.3.3 Ship finance

Banks have traditionally been the main source of credit for maritime trade from ancient times to the present day [18]. International payments and transfers currently cost about 5 to 20 percent of the original money as transaction costs [19] and may take several days to reach the destination. This can be done very easily, quickly and securely through cryptocurrencies. The cost of transactions through blockchain and cryptocurrencies can be extremely small and can be done almost instantly [19]. Therefore, blockchain payment is faster, more economical and more secure than the SWIFT centralized banking system [20].

2.3.4 Ship insurance

Effective information sharing is extremely crucial in ships insurance. The process of insurance through blockchain will be much easier than before. This is because the information is verified and integrated, and the insurance applicant's information can be easily tracked [21]. In addition, automatic setting and enforcement of premiums can also be done with blockchain [22]. The insurance litigation process is usually complex due to the large number of individuals, entities, participants, and third parties, and the transparency of the information needed to process claims is currently inadequate [21]. With blockchain it will be transparent, and smart contracts can speed up the review process, approve requests, and shorten dispute resolution times [22].

2.4 Identifying adoption factors

A framework is needed to examine the factors influencing blockchain adoption in maritime trade. TOE framework was presented by Tornatzky and Fleischer in 1990, which examines the factors to the adoption of any technology and analyzes them from three perspectives: technological, organizational and environmental [23]. Factors influencing blockchain adoption in Iran’s maritime trade were gathered from reviewing a collection of available articles and reviewing the literature and interviewing experts.

2.4.1 Technological factors

The availability of blockchain-specific tools such as smart contracts and the Internet of Things is an important feature of blockchain technology that plays a key role in its acceptance in maritime trade. One of the main factors in accepting any technology is the technology-related complexities. These complexities make it difficult for users to understand and work with blockchain. Complexity actually requires special talent, ability and expertise in relation to working with blockchain. Ease and convenience of working with technology has always been one of the basic factors of acceptance of any technology in the past. Another factor is the size and volume of the blockchain, which is constantly getting bigger and more voluminous. At present, we see a lot of transactions in the current blockchain that can reduce the quality and efficiency of the blockchain [24]. Infrastructure facilities are another important factor in adopting blockchain in maritime trade, which means the ability to support and adapt the current technology for accepting blockchain [25]. Compatibility is another major factor in the field of technology, which can be described as the ease of integrating blockchain in relevant platforms in maritime trade [26]. The benefits of blockchain is another important factor, which is the amount of value that blockchain can add to maritime trade [27]. Finally, security and confidentiality is another essential factor in the field of technology, which means that the shared information is sufficiently secure and confidential and cannot be changed during the integration process. Another factor in this area is the immaturity of technology. For example, the problem of blockchain scalability and the size of the blockchain database in the long run [28].

2.4.2 Organizational factors

The organizational domain includes all the factors and items that are related to the basic internal issues of an organization. For example, the availability of training facilities is an important factor in this regard, which means the existence of appropriate training facilities for employees of organizations to adopt blockchain [29]. Another important factor in this field is the existence of top management, which is the ability of high-level and top managers to provide guidance and resources related to blockchain acceptance, continuously and consistently. Company size, which means number of employees and output size, is the next important factor in accepting blockchain in maritime trade [30] because large companies can more easily access the resources needed to change strategy than smaller companies. In addition, smaller companies are often reluctant to conduct new business operations and provide training to their employees due to the existence of multiple risks [31]. Organizational culture, which includes the pattern of behavior and performance of organizational employees in maritime trade, is another important factor for accepting blockchain [26]. It influences how companies respond to external pressures and their strategic business decisions [32]. Another important issue in the field of organizational factors is the existence of investment costs, which is the availability of sufficient financial resources needed to implement and develop and accept blockchain-related tools in maritime trade [2]. The ability of human resources is also another essential factor in this area. This means that maritime business professionals are sufficiently trained and knowledgeable in the field of working with blockchain [33,34]. Another factor is the reluctance to accept new and innovative systems. Disruptive technologies such as blockchain, requires the replacement of the legacy systems, this issue can cause reluctance and hesitation in organizations to accept technology [35].

2.4.3 Environmental factors

Environmental factors include factors related to areas of regulation, industry characteristics, market competition, and the relationship between companies, which include government policies, competitive pressure, organizational trust and market turmoil. Competitive pressure is an important factor related to the external maritime trade environment and means the relentless efforts of maritime logistics companies to prove their worth to their shareholders and investors [35]. Government support and policies is another important factor in this area, including the ability of government agencies to provide the necessary assistance and enact new rules and regulations to advance the acceptance of blockchain in maritime trade [36]. Inter-organizational trust is another important factor that can be defined as: the acceptance and approval of blockchain technology by the external maritime trade environment, in addition, shareholder pressure is another important and key factor in this area that can be considered as constant expectations of shareholders and investors in the maritime trade industry [2]. Businesses usually respond to business market pressures to adopt new technologies in different ways [33]. Therefore, it can be said that market turmoil, which includes uncertainty and instability of maritime logistics services, can affect the acceptance of blockchain in maritime trade [37]. One of the important factors for accepting blockchain is its standardization. This can accelerate the advancement of blockchain acceptance in maritime trade, because with an internationally approved platform, we can have a more secure market and faster innovative developments. Another important factor in this area is the lack of customer awareness, which means not having enough information and knowledge about working with systems based on blockchain technology in the field of maritime transport and its supply chain [39]. Another important factor is related to regulatory and legal challenges. Because blockchain has disrupted many traditional patterns of international trade, regulatory and legal challenges have arisen that need to be addressed.

3.Methodology

This research is deemed as applied research in terms of purpose and a descriptive survey in nature because users can use its results. The research method is descriptive and documentary and implements a survey method. This is because to identify the factors, the theoretical foundations and background of research and interviews with experts are used as documents, and also to confirm and hierarchize the factors, a researcher-made questionnaire using Delphi technique and AHP were used. Quantitative analysis was also done using SPSS software. This research employed a Delphi study to elicit expert insight into identifying the key factors facing blockchain adoption in Iran's maritime trade. For this reason, 10 experts from top managers of Iran's port and maritime organization were selected. Delphi studies are frequently conducted in deductive research but also combined with qualitative data-capturing in order to be more pragmatic. It's especially beneficial for delving into complex phenomena where there's disagreement, a lack of data, or future forecasts are being made [38]. In this study, Kendall correlation coefficient was used to determine the scale of consensus among panel members. The Kendall Correlation Coefficient is a scale for determining the degree of correlation and agreement between several categories related to N objects or individuals, which is shown in Eq. (1).

$$W = \frac{s}{\frac{1}{12}k^2(N^3 - N)} \tag{1}$$

where in Eq. (1) *n* stands for objects, *m* stands for judges and S stands for the sum of squared deviations.

The value of this scale is one when there is complete coordination or complete agreement and zero when there is no complete coordination. There are two statistical criteria for deciding whether to stop or continue Delphi rounds. They can be terminated whenever one of these two factors is observed. The first criterion is a strong consensus among panel members, which is determined by the Kendall's W. In the absence of such a consensus, the stability of this coefficient or its slight growth in two consecutive rounds indicates that there has been no increase in the agreement of the members and the polling process should be stopped [39]. In the next phase we used AHP to hierarchize the factors. The Analytic Hierarchy Process (AHP) is a math and psychology-based system for organizing and analyzing complicated decisions. It was created in the 1970s by Thomas L. Saaty and has subsequently been enhanced. It consists of three parts: the ultimate aim or problem you're attempting to address, all feasible solutions (referred to as alternatives), and the criteria you'll use to evaluate the alternatives. By quantifying its criteria and alternative possibilities, and tying those parts to the broader purpose, AHP gives a coherent foundation for a needed conclusion. The application of the methodology consists of establishing the importance weights to be associated to the criteria in defining the overall goal. This is done by comparing the criteria pairwise using the ExpertChoice software [40].

4. Results and Discussion

In the first Delphi round, a questionnaire that included 21 effective factors in 3 categories was given to 10 experts from the managers of the Ports and Maritime Organization to rate each item based on a 5-point Likert scale. Experts were also asked to indicate if they had a factor other than the one mentioned. The reliability of the questionnaire in the first stage was equal to 0.908 and because it is higher than 0.7 is acceptable. Kendall's W was also 0.136 and it should be examined in the next round of Delphi, whether this coefficient will improve significantly or not. The results of the first round of Delphi are given in Table 1. In the second round of Delphi, at first the factors that have averaged less than 3 in the first round of Delphi are eliminated. The results showed that all factors have an average above 3, so none are eliminated. In the second round of Delphi, the first stage questionnaire was again given to the experts to rate each index as in the first stage. Also in this round, the average score of the first round of Delphi was set so that experts could make decisions based on the total average. During this period, many experts confirmed their views in the first stage. The results of the second round of Delphi are given in Table 2. The reliability and correlation coefficient of Kendall in the second round are equal to 0.784 and 0.176, respectively. The results of double rounds of Delphi method in the research show that for the following reasons, consensus has been reached between experts and it is possible to end the repetition of rounds. In the second round of Delphi, at least 90% of the respondents considered the indexes to have high and very high scores (average above 3). The standard deviation of experts' responses about the importance of factors in the second round compared to the first round has decreased significantly. Kendall's W in the second round is equal to 0.176. Given that the number of respondents was 10, this amount of Kendall coefficient is quite significant [39]. The difference between Kendall's W in the second round and the first round has increased only 0.04. This coefficient or the degree of consensus among panel members between two consecutive rounds does not show significant growth. This lack of growth is one of the reasons to stop the Delphi rounds [39]. Using the AHP method, the factors that were confirmed by the Delphi method in the previous step are prioritized in this section. The steps of this method are given below. In this step, AHP hierarchical analysis method is used to determine their importance and weight. First, comparisons of criteria and sub-criteria were created and provided to experts. The number of experts in this section is 10. After completing the pairwise comparison matrices, the inconsistency rates of each were calculated, all of which were less than 0.1, which indicates the stability and compatibility of the matrices. Then the pairwise comparisons of the experts were integrated by the geometric mean method and then entered into the ExpertChoice software to determine the weight. The following are the results of pairwise comparisons and weights.

Table 1. Delphi Frist Round Results

Std. Deviation	Mean	Max	Min	Sub criteria	Criteria
0.972	3.5	4	1	Blockchain complexity	**Technological**
1.135	3.8	5	1	Blockhcain adaptability	
0.738	4.1	5	3	Blockchain benefits	
0.568	4.1	5	3	Security and Confidentiality	
1.075	3.4	4	1	Technology’s immaturity	
0.568	4.1	5	3	Infrastructural facilities	
0.994	3.9	5	2	Blockchain’s special tools	
1.174	3.6	5	1	availability of training facilities	**Organizational**
1.337	3.7	5	1	Top management	
1.059	3.3	5	2	Firm size	
0.789	3.2	4	2	Organizational culture	
0.994	3.1	4	1	Investment cost	
1.197	3.1	4	1	Human resources abilities	
1.179	3.5	5	1	Reluctance to technology	
1.179	3.5	5	1	Governments’ policies and support	**Environmental**
1.337	3.3	5	1	Competitive pressure	
1.135	3.8	5	1	Inter-organizational trust	
1.252	3.3	5	1	Stakeholders’ pressure	
1.265	3.4	5	1	Standardization	
1.174	3.4	5	1	Regulatory and legal issues	
1.135	3.8	5	1	Customers’ lack of awareness	

Table 2. Delphi Second Round Results

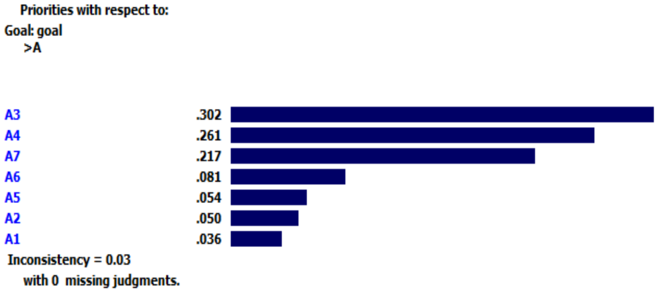
Std. Deviation	Mean	Max	Min	Code	Sub criteria	Criteria
0.699	3.6	4	2	A1	Blockchain complexity	**Technological**
0.876	3.9	5	2	A2	Blockhcain adaptability	
0.516	4.4	5	4	A3	Blockchain benefits	
0.516	4.4	5	4	A4	Security and Confidentiality	
0.699	3.6	4	2	A5	Technology’s immaturity	
0.568	4.1	5	3	A6	Infrastructural facilities	
0.994	3.9	5	2	A7	Blockchain special tools	
0.949	3.7	5	2	B1	availability of training facilities	**Organizational**
0.994	3.9	5	2	B2	Top management	
1.059	3.3	5	2	B3	Firm size	
0.789	3.2	4	2	B4	Organizational culture	

0.675	3.3	4	2	B5	Investment cost	
0.949	3.3	4	2	B6	Human resources abilities	
0.966	3.6	5	2	B7	Reluctance to technology	
0.789	3.8	5	2	C1	Governments' policies and support	**Environmental**
0.966	3.6	5	2	C2	Competitive pressure	
0.876	3.9	5	2	C3	Inter-organizational trust	
0.966	3.6	5	2	C4	Stakeholders' pressure	
0.823	3.7	5	2	C5	Standardization	
0.843	3.6	5	2	C6	Regulatory and legal issues	
0.667	4	5	3	C7	Customers' lack of awareness	

Table 3. Weight and rank of the main criteria (Expert Choice)

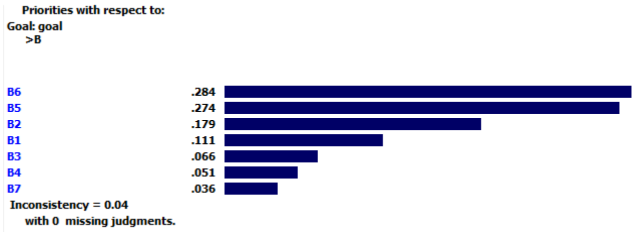
According to Table 3, the technological factor with a weight of 0.743 has gained the first rank. Organizational factor with a weight of 0.132 has gained the second rank and an environmental factor with a weight of 0.125 has gained the third rank. The next step is the pairwise comparison of technological factors. The technology criterion has 7 sub-criteria. The incompatibility rate of this pairwise comparison is equal to 0.03. We enter the pairwise comparisons in the Expert choice software, where the criteria weights are calculated and they are shown in table 4.

Table 4. Technological criteria weight (Expert Choice)



According to Table 4 among the technology sub-criteria, the blockchain benefits with a weight of 0.302 have gained the first rank. The security and confidentiality of blockchain with a weight of 0.261 is ranked second and special tools of blockchain with a weight of 0.217 are ranked third. The organizational criterion has 7 sub-criteria. The incompatibility rate of this pairwise comparison is equal to 0.04. We enter the pairwise comparisons in the Expert Choice software, where the criteria weights are calculated and shown in Table 5.

Table 5. Organizational criteria weight



According to table 5, among the organizational sub-criteria, the ability of human resources with a weight of 0.284 has gained the first rank. The cost of investment, with a weight of 0.274, is second and the existence of top management with a weight of 0.179 is third. The environmental criterion has 7 sub-criteria, the incompatibility rate of this pairwise comparison is equal to 0.06. We enter the pairwise comparisons in the Expert choice software, where the weights of the criteria are calculated and shown in table 6.

Table 6. environmental criteria weight

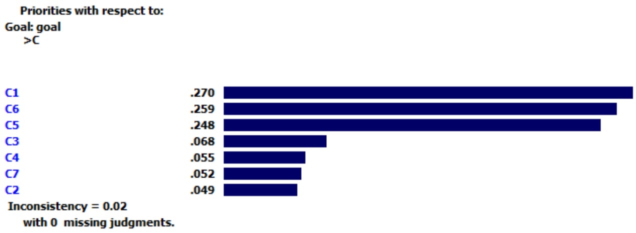


Table 6 shows that government support and policy (0.270) is the top environmental sub-criterion, followed by regulatory and legal challenges (0.259) and standardization (0.248). The final weight of each sub-criterion is calculated by multiplying the dimension weight, the standard weight, and the relative weight, using ExpertChoice software. Table 7 presents the results. Among the 21 sub-criteria, blockchain benefits is the highest, blockchain security and confidentiality is the second, and blockchain special tools is the third.

Table 7. Final weight of criteria

Final rank	Sub-criteria final weight	Sub-criteria relative weight	Sub-criteria	Criteria weight	Criteria
12	0.0267	0.036	Blockchain complexity	0.743	**Technological**
7	0.0372	0.05	Blockchain adaptability		
1	0.2244	0.302	Blockchain benefits		
2	0.1939	0.261	Security and confidentiality		
5	0.0401	0.054	Technology immaturity		
4	0.0602	0.081	Infrastructural facilities		
3	0.1612	0.217	Blockchain special tools		
14	0.0147	0.111	Availability of training facilities	0.132	**Organizational**
13	0.0236	0.179	Top management		
15	0.0087	0.066	Firm size		
18	0.0067	0.051	Organizational culture		
8	0.0362	0.274	Invesment cost		
6	0.0375	0.284	Human resources abilities		
21	0.0048	0.036	Reluctance to technology		
9	0.0338	0.27	Governments' policies and support	0.125	**Environmental**
20	0.0061	0.049	Competitive pressure		
16	0.0085	0.068	Inter-organizational culture		
17	0.0069	0.055	Stakeholders' pressure		
11	0.0310	0.248	Standardization		
10	0.0324	0.259	Regulatory and legal issues		
19	0.0065	0.052	Customers' lack of awareness		

5. Conclusion

Blockchain technology is an emerging and disruptive innovation that has the potential to transform international trade and has attracted worldwide attention in recent years. However, its adoption in the maritime industry is still nascent and faces various challenges. Therefore, the maritime industry and its stakeholders are exploring the opportunities and benefits of this technology for their business processes. Although implementing new technology can entail high costs, it can also yield significant financial gains if the feasibility and suitability are carefully assessed. Blockchain technology offers a novel and secure solution for maritime trade, as it integrates multiple features that facilitate fast, transparent, paperless and cost-effective transactions, such as a decentralized ledger, smart contracts and trustworthy and secure networks that reduce the intermediation of third parties. Hence, it is plausible to expect that blockchain-based technologies will play a key role in the future of maritime trade and transportation. In this article, we examined the application of blockchain technology in maritime trade, with a focus on its adoption in Iran's maritime trade. We adopted the Technology-Organization-Environment (TOE) framework to identify three main categories of factors that influence the decision to adopt blockchain in Iran's maritime trade. We collected 21 key factors from an extensive and systematic literature review and interviews with 10 managers of Iran's port and maritime organization and maritime transportation. Then, we used the Delphi method to validate these factors in two rounds with 10 Iranian maritime trade experts and finally, we applied the Analytic Hierarchy Process (AHP) method to rank them according to their importance. The results revealed that although blockchain is regarded as a promising technology in international maritime trade, there are still barriers and enablers for its acceptance in Iranian maritime trade. The results indicate that among the main categories (technology, organization, environment), the category of "technology" was ranked first. Moreover, the sub-categories of "blockchain benefits", "human resource capability" and "government support and policies" were ranked first in the "technology", "organization" and "environment" categories, respectively, and finally among all the sub-categories, "blockchain benefits", "security and confidentiality" and "specific blockchain tools" obtained the highest ranks. This would provide a better understanding of blockchain technology and address the concerns about its adoption at the logistics business level.

6. References

1. Brilliantova, Vlada & Thurner, Thomas Wolfgang, 2019. "Blockchain and the future of energy," Technology in Society, Elsevier, vol. 57(C),

2. Allison, I. (2016), "Shipping giant Maersk tests blockchain-powered bill of lading", International Business Times,

3. Park, T. (2018), "Blockchain Is About to Revolutionize the Shipping Industry",

4. Allison, I. (2017), "Maersk and IBM want 10 million shipping containers on the global supply blockchain by year-end", International Business Times, 8 March 2017

5.Chang, S., Chen, Y., & Lu, M. (2019). Supply chain re-engineering using blockchain technology: A case of smart contract based tracking process. Technological Forecasting and Social Change, 144, 1-11.

6. Microsoft. 2018. "How Blockchain will Transform the Modern Supply Chain".

7. Johnson, M. E. 2006. "Supply Chain Management: Technology, Globalization, and Policy at a Crossroads." Interfaces 36 (3): 191–193

8. Lambert, D. M., and M. G. Enz. 2017. "Issues in Supply Chain Management: Progress and Potential." Industrial Marketing Management 62 (Supplement C): 1–16

9. Bustillos, M. (2013), "The Bitcoin Boom", The New Yorker, 1 April 2013.

10. Nakamoto, S. (2008). Bitcoin: A peer-to-peer electronic cash system. available at: https://bitcoin.org/bitcoin.pdf

11. Deloitte (2018), Blockchain, legal implications, questions, opportunities and risks, Deloitte Legal, March 2018

12. Reed Smith. 2016. "Electronic Bills of Lading: Another Step Forward!" Reed Smith. https://www.reedsmith.com/en/perspectives/2016/01/electronic-bills-of-lading-another-step forward

13. Dubovec, M. 2005. "The Problems and Possibilities for Using Electronic Bills of Lading as Collateral." Arizona Journal of International & Comparative Law 23: 437

14.Seatrade. 2018b. "Where the Digital and Physical World's Meet the Biggest Risk for Blockchain." Seatrade Maritime News. http://www.seatrade-maritime.com/news/europe/where-the-digital-and-physicalworld-s-meet-the-biggest-risk-for-blockchain.html

15.Kshetri, N. (2018). 1 Blockchain's roles in meeting key supply chain management objectives. Int. J. Inf. Manag., 39, 80-89.

16.Shankar, R., Gupta, R., & Pathak, D. (2018). Modeling critical success factors of traceability for food logistics system. Transportation Research Part E-logistics and Transportation Review, 119, 205-222.

17.Wu, I., Chuang, C., & Hsu, C. (2014). Information sharing and collaborative behaviors in enabling supply chain performance: A social exchange perspective. International Journal of Production Economics, 148, 122-132.

18.Kavussanos, Manolis & Tsouknidis, Dimitris. (2011). Default Risk Drivers in Shipping Bank Loans.

19.Martin, D. 2017. Key Business Drivers and Opportunities in Cross-Border Ecommerce. Amsterdam: Payvision.

20.Yuan, Y., and F. Y. Wang. 2016. "Blockchain: The State of the Art and Future Trends." Zidonghua Xuebao/ActaAutomatica Sinica 42 (4): 481–494.

21.Nath, I. 2016. "Data Exchange Platform to Fight Insurance Fraud on Blockchain." In Proceedings of 2016 IEEE 16th International Conference on Data Mining Workshops (ICDMW), Barcelona, Spain: IEEE, 821–825. doi:10.1109/ICDMW.2016.0121

22.Püttgen, F., and M. Kaulartz. 2017. "Insurance 4.0: Use of Blockchain Technology and Smart Contracts in the Insurance Sector." ERA Forum 18 (2): 249–262. doi:10.1007/s12027-0170479-y

23.Tornatzky, L. G., Fleischer, M., & Chakrabarti, A. K. (1990). Processes of technological innovation: Lexington books.

24.Al-Jaroodi, J., & Mohamed, N. (2019). Blockchain in Industries: A Survey. IEEE Access, 7, 36500-36515.

25.Hughes, D.L., Dwivedi, Y.K., Misra, S., Rana, N.P., Raghavan, V., & Akella, V. (2019). Blockchain research, practice and policy: Applications, benefits, limitations, emerging research themes and research agenda. Int. J. Inf. Manag., 49, 114-129.

26.Schuetz, S., Venkatesh, V., 2019. Blockchain, adoption, and financial inclusion in India: Research opportunities. Int. J. Inf. Manage.

27.Queiroz, M., & Wamba, S. (2019). Blockchain adoption challenges in supply chain: An empirical investigation of the main drivers in India and the USA. Int. J. Inf. Manag., 46, 70-82.

28.Lindman, J., Tuunainen, V. K., & Rossi, M. (2017). Opportunities and risks of Blockchain Technologies–a research agenda

29.Morkunas, V.J., Paschen, J., & Boon, E. (2019). How blockchain technologies impact your business model. Business Horizons, 62, 295-306.

30.Nilashi, M., Ahmadi, H., Ahani, A., Ravangard, R., & Ibrahim, O. (2016). Determining the importance of Hospital Information System adoption factors using Fuzzy Analytic Network Process (ANP).

Technological Forecasting and Social Change, 111, 244-264.
31.Jonathan Q. Morgan (2012) Regional clusters and jobs for inner city workers: the case of transportation, distribution, and logistics, Community Development,
32.Dubey, R., Gunasekaran, A., Childe, S., Roubaud, D., Wamba, S., Giannakis, M., & Foropon, C.R. (2019). Big data analytics and organizational culture as complements to swift trust and collaborative performance in the humanitarian supply chain. International Journal of Production Economics, 210, 120-136.
33.Dai, Jing & Chan, Hing & Yee, Rachel. (2018). Examining moderating effect of organizational culture on the relationship between market pressure and corporate environmental strategy. Industrial Marketing Management. 74.
34.Min, H. (2019). Blockchain technology for enhancing supply chain resilience. Business Horizons, 62, 35-45.
35.Angelis, J., & Silva, E.H. (2019). Blockchain adoption: A value driver perspective. Business Horizons, 62, 307-314.
36.Montecchi, M., Plangger, K., & Etter, M. (2019). It's real, trust me! Establishing supply chain provenance using blockchain. Business Horizons, 62, 283-293.
37.Wang, Y., Singgih, M., Wang, J., & Rit, M. (2019). Making sense of blockchain technology: How will it transform supply chains? International Journal of Production Economics, 211, 221-236.
38.Kosow, H., & Gassner, R.J. (2008). Methods of Future and Scenario Analysis: Overview, Assessment, and Selection Criteria.
39.Schmidt, RC. (1997). ‘Managing Delphi surveys using nonparametric statistical techniques,’Decision Sciences, 28, (3), 763-774.
40.Saaty, T.L., and Aczel, J., 1983, On synthesizing judgments, Journal of Math. Psychology,