A Knowledge Mapping Analysis on the Blockchain Research in the Maritime Sector†

해운부문 블록체인 연구에 대한 지식 매핑 분석

방주아*·이상윤**
Fang, Shuya · Lee, Sang-Yoon

Contents

Abstract: Blockchain, as an emerging distributed technology, has been widely applied in various industries and fields. This paper aims to analyze the research on blockchain technology in the maritime industry by using bibliometrics and visualization methods with samples from the Web of Science Core Collection database. Next, Cite Space software is used to visualize the publication countries and institutions, reference co-citation, author co-citation, keyword co-occurrence for timezone view, timeline view, and bursts. A multi-dimensional perspective of the current status, trends, and hotspots is obtained to provide certain policy implications for enhancing blockchain research capabilities while activating its application in the maritime industry.

Key words: Blockchain Technology, Maritime Research, Visualization

---

† This work was supported by INHA UNIVERSITY Research Grant
* First author, Ph.D. Graduate School of Logistics, INHA University
** Corresponding author, Graduate School of Logistics, INHA University, sylee@inha.ac.kr

Ⅰ. Introduction

As economic globalization enters a new stage, the global economy is closely linked through international trade, international investment, talent flow, and new information technology of unprecedented scale. In the process of economic globalization, countries in the world carry out international trade through comparative advantage, and the volume of international trade goods is mostly fulfilled through maritime transport, which plays an essential role in guaranteeing the smooth flow of the global logistics supply chain. How to develop maritime transport to support the rapid development of international trade is a topic worth thinking about.

As an emerging technology, blockchain technology utilizes decentralization, transparency, traceability, visibility, and cryptographic security scenarios. Therefore, it has become a legitimate disruptor in various industries such as in finance (Ahluwalia et al., 2020), insurance (Brophy, 2019), healthcare (Zubaydi et al., 2019), education (Kazakzeh et al., 2019), and logistics (Jain et al., 2020). The functional characteristics of blockchain technology enable it to be used in international trade application scenarios involving various roles, high commercial value, long information transmission chains, and trade secrets. The maritime industry covers a vast array of parts, including shippers, shipping companies, freight forwarders, port and terminal operators, inland transport carriers, and customs. It involves transnational, cross-governmental, and cross-industrial information exchange. Therefore, in theory, the maritime industry should be one of the most suitable areas for blockchain applications.

The TradeLens platform led by Maersk and IBM currently uses distributed ledger technology to digitize the supply chain, complete document approval, transmission, and network node permission setting in a blockchain environment, thus greatly simplifying the process and reducing the costs. The Global Shipping Business

Network (GSBN), initiated by CargoSmart, has focused its attention on the issue of electronic bill of lading. Electronic bill of lading can reduce the cost of paper document flow, speed up the bill of lading transmission, and enhance convenience in carrying out bill of lading pledges and other financial services, reducing the risk of under reporting. Recently, the International Organization for Standardization ISO/TC154 voted to adopt the standard "Blockchain maritime electronic bill of lading data interaction process", standard project number ISO NP 5909, which aims to standardize the architecture, functional requirements, business processes, interfaces and data formats of the blockchain electronic bill of lading system, providing standard guidelines and a standard basis for the flow and verification of maritime electronic bills of lading through the blockchain system. To promote the application of blockchain electronic bill of lading and provide a trustworthy digital foundation for international trade.

Blockchain has been a critical research issue in the maritime sector: the possible advantages of blockchain technology in shipping (Jugović et al., 2019); possible benefits and hindrances of the implementation of blockchain technology in the Greek maritime industry (Papathanasiou et al., 2020). However, these studies are scattered and do not provide a quick insight into the application of blockchain technology in the maritime industry. It is assumed that all these kinds of literature has been combed as a whole to obtain the current status and application trends of blockchain technology in the maritime industry.

Scientific knowledge mapping is described as the process, methods, and tools for analyzing a knowledge domain to identify features or meanings and visualize them in a comprehensive and visible format to represent concepts, knowledge, and links in a visual/graphical form. CiteSpace software is one of the most commonly implemented tools for knowledge mapping. It is precisely in support of the visualization of the analysis process, which can generate co-citation networks to reveal the structure of a specific research area based on paper citations (Chen et al., 2010). Under these conditions, this paper utilizes CiteSpace software to visualize blockchain technology research in the maritime industry to understand the current status, hotspots, and trends in this field.

Through this study, it is expected that national research capabilities and networks of scholars and institutes for blockchain research in the maritime sector can be identified, and from the viewpoint of Korea, some policy implications for blockchain research and its industrial application can be obtained by grasping the development direction and trends of major issues of blockchain research in the maritime sector. The composition of this study is as follows. Section 1 is an introduction, while Section 2 focuses on research design, which includes research methods and data collection. Section 3 analyzes the network characteristics, major research trends, and critical topics surrounding blockchain research in the maritime sector. Section 4 deals with the policy implications that can be obtained from this study.

Ⅱ. Research Design

Reviewing and examining previous research efforts is viewed as a rewarding activity in academia as the advancement of knowledge and theory in academic disciplines depends on the theoretical and empirical contributions of individual research. Researchers further propose that the topic of journal articles is an indicator of the direction of research and needs to be analyzed regularly with knowledge accumulation (Li et al., 2017). As a relatively young discipline, reviewing and analyzing research on blockchain technology is particularly important for the development process and benefits to the maritime industry.

The research on blockchain technology in the maritime industry through CiteSpace software is mainly divided into three parts: data preparation, data analysis, and visualization analysis, which are finally expressed in the form of graphs and texts.

1. Research Method

Scientific knowledge mapping (abbreviated as knowledge mapping) is a graphical presentation of the development process and structural relationships in practical scientific knowledge (Nimsai et al., 2020). Its function is to enable researchers to have a clear grasp of disciplinary structure, research content, disciplinary relationships, and hotspots, as well as to predict the frontiers and trends of disciplinary development. The methods of knowledge mapping can be broadly classified into three categories: bibliometric methods (e.g. coupling analysis, citation analysis, co-citation analysis, keyword co-occurrence analysis, link analysis, word frequency analysis), statistical analysis methods (e.g. factor analysis or principal component analysis, multi-dimensional scale analysis), and data mining methods (cluster analysis, self-organizing feature map, pathfinder network, social network analysis) (Criscuolo et al., 2007; Capó-Vicedo et al., 2011). Knowledge mapping is generally based on Bibexcel, HistCite, CiteSpace, VOSviewer, SPSS, Thomson Data Analyzer, Ucinet NetDraw, etc. Based on the objectives of this study and the availability of mapping tools, this paper chooses to use a bibliometric approach to analyze the current state of blockchain development in the maritime industry and selects CiteSpace software to present the graphs and tables.

CiteSpace software is used to map scientific knowledge (Chen and Song, 2019). In the CiteSpace software, descriptive statistical analysis and cluster analysis are usually used to study current status and future trends. The descriptive statistical analysis depicts the current status of research development, including an overall analysis of the references co-citation networks, distribution of publications and citations, an analysis of published journals, issuing institutions, and collaborative networks. The basic property of cluster analysis is the analytical process of forming a group of physical or abstract objects into multiple classes composed of similar things. Objects within the same cluster have remarkable similarities; otherwise, they have significant dissimilarities. Cluster analysis is used for keyword co-occurrence to get the research focal point.

Based on the above explanation, this paper conducts a bibliometric analysis of blockchain technology research in the maritime industry using the CiteSpace software to show the current status, trends, and hotspots through data analysis and information mining.

2. Data Collection

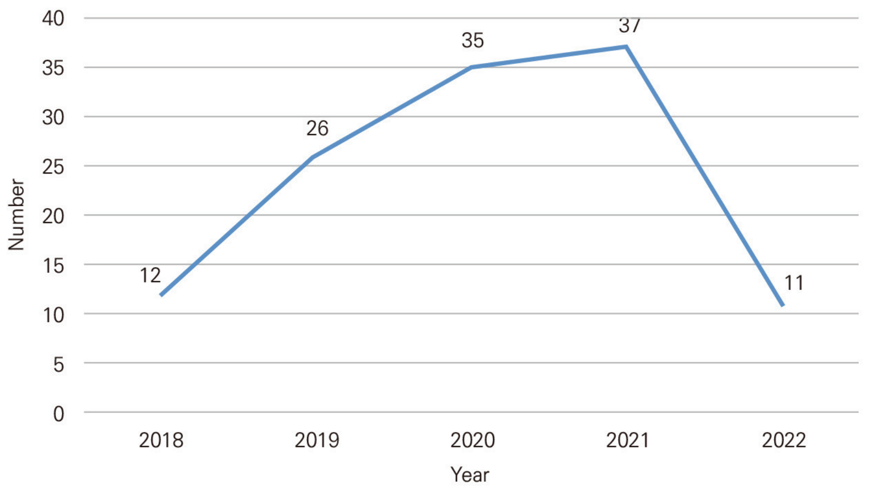
This paper aims to analyze the latest studies of blockchain technology in the maritime industry, and to be more objective, the Web of Science (WoS) database is used to obtain samples. WoS is a globally-leading literature index database covering natural science, social science, arts, and liberal arts. The Web of Science Core Collection is a collection of more than 20,000 peer-reviewed, high-quality scholarly journals from more than 250 scientific, social science, and humanities disciplines worldwide. Data extraction from the Web of Science core collection guarantees the reliability and authenticity of the data source.

The selection of search topics for the current research was based on the study of Jhang and Lee (2016). The authors identified themes and trends in the maritime field by examining 303 journal papers published between 2000 and 2014 by adopting keyword network analysis and extracted the top 20 keywords by the degree centrality method. In the current study, keywords with a high correlation with blockchain were preferentially selected among keywords presented in the above study, and a number of additional keywords such as IMO and Bill of Lading were included to expand searching range. The search topics combined with blockchain are maritime, shipping, marine, port, sea, seaborne trade, sailing, navigation, nautical, liner, vessel, intermodal, carrier, container, bill of lading, and IMO.

Document types contain articles, proceeding papers, review articles, and editorial materials. Since 2017, there have been 394 articles from the WoS core collection, which were filtered by manually reviewing the titles and abstracts. There were ultimately 121 articles reflecting the blockchain issues in the maritime industry from 2018 to 2022, and in consequence, the analysis in this paper is based on these 121 articles. The specific number of papers per year is displayed in Figure 1.

The data grows every year and offers an upward trend. There are only 12 articles in 2018, which indicates that the research on blockchain technology in the maritime industry started late and is still a relatively new research area. The number of articles published from 2019 to 2021 has been gradually increasing, and 11 articles have also been published until April 2022.

❙ Figure-1. Distribution of the Annual Number of Articles for Studies ❙



Ⅲ. Data Analysis

1. Literature Characteristics Analysis

1) Country Collaboration Network

The top 10 nations that have made significant contributions to the total publications are shown in Table 1. China is the largest contributor, with 24 articles published since 2018, followed by the Republic of Korea since 2019. Both the United States and England have published eight articles starting in 2019. In general, the amount of outputs is related to the number of research institutions, the availability of research funds, and the degree of innovation in new technology. The fact that China is the most productive country in this field indicates a complete interest in this kind of research.

Country collaboration network expresses the degree of cooperation among researchers located in different countries. To establish a collaboration network, the concept of centrality should be employed. The centrality of nodes is a graph theory attribute that can quantify the importance of the location of nodes in the network. Degree centrality is defined as the number of links incident upon a node. Closeness centrality is the average length of the shortest path between the node and all other nodes in a graph. Betweenness centrality measures a vertex within a graph. Eigenvector centrality is a measure of the influence of a node in a network. In this study, worldwide research network properties were analyzed by the concept of betweenness centrality in consideration of the space limitation. The application of betweenness centrality in CiteSpace is guided by the structural hole theory. Nodes with a greater betweenness centrality perform an essential role in mediating the flow of connections between nodes, facilitating the seamless operation of the entire network. Betweenness centrality indicates the extent to which a node acts as an ‘intermediary’ for other nodes in the network, and it measures the importance of a node in the network. Nodes with a high betweenness centrality tend to be observed in paths connecting different clusters (Wang et al., 2014). Generally, betweenness centrality evaluates the number of shortest paths in the network to which a given node belongs as a percentage. A value greater than 0.1 is claimed to be high betweenness centrality. In other words, cooperation with other nodes is relatively active.

The nodes with purple tree rings in the figure suggest that the node has a high betweenness centrality. The thicker the purple tree rings, the greater the centrality and strong connection with other nodes. The network of cooperative countries is shown in Figure 2. The top-ranked item by betweenness centrality is China, with a centrality of 0.26, indicating that China cooperates more with other countries. The second one is India (0.23), and the third is the United States (0.16). Australia and Saudi Arabia have a centrality of 0.1, respectively. These five countries with centrality greater than or equal to 0.1 indicate a relatively high level of cooperation and interaction.

Figure-2. A Visualization of the Country Collaboration Network

Table-1. Top 10 Countries of Collaboration Network (frequency)

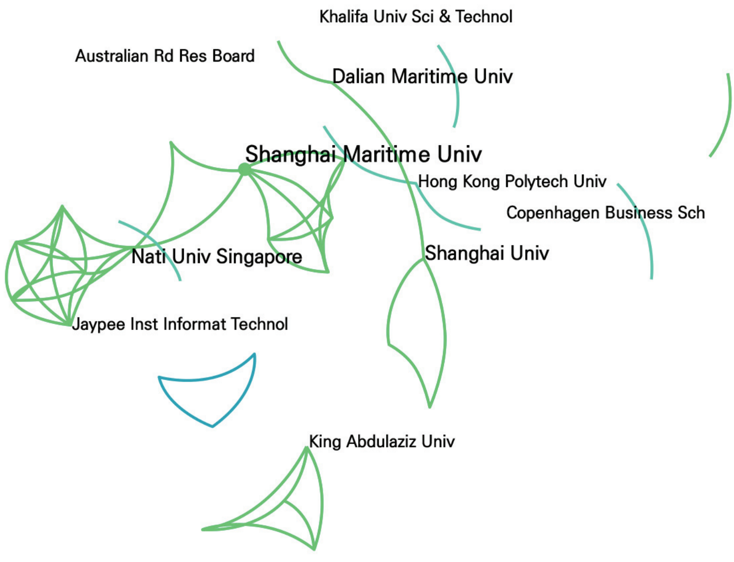
Rank	No.	Centrality	Year	Country
1	24	0.26	2018	P.R.China
2	9	0.00	2019	Republic of Korea
3	8	0.16	2019	United States
4	8	0.09	2019	England
5	7	0.06	2018	Singapore
6	6	0.23	2020	India
7	6	0.10	2019	Australia
8	5	0.10	2021	Saudi Arabia
9	4	0.04	2019	Taiwan
10	4	0.00	2019	United Arab Emirates

2) Institution Collaboration Network

The network of institution collaboration shows the affiliation of the authors of the publications. The top 10 institutions that have contributed the most to the total output are listed in Table 2. From Figure 3, it can be identified that the institutional collaboration network comprised 105 nodes (institutions) and 97 collaborative links from 2018 to 2022, with the size of the nodes representing the volume of publications by the institutions. The thinness of the links (97) between institutions indicates a low level of cooperation. Moreover, there is no node with a high betweenness centrality. The nodes with tree rings are not shown in purple, indicating that the connection and collaboration among these institutions are not high.

Shanghai Maritime University and Shanghai University are the top two universities, but the centrality of these two schools is just 0.01, which means that cooperation does not exist. The National University of Singapore and Dalian Maritime University are in third and fourth places, but the centrality is only 0.01. The centrality of the other institutions is zero, indicating that there is no cooperation and connection between these institutions. It is necessary to strengthen cooperation to promote knowledge integration in this field.

▌Figure-3. A Visualization of the Institution Collaboration Network▐



▌Table-2. Top 10 Institution of Collaboration Network (frequency)▐

Rank	No.	Centrality	Year	Country
1	4	0.01	2022	Shanghai Maritime University, P. R. China
2	3	0.01	2021	Shanghai University, P. R. China
3	3	0.01	2021	National University of Singapore, Singapore
4	3	0.01	2021	Dalian Maritime University, P. R. China
5	2	0.00	2019	Khalifa University of Science and Technology, UAE
6	2	0.00	2019	Copenhagen Business School, Denmark
7	2	0.00	2020	Nanyang Technol University, Singapore
8	2	0.00	2020	Hong Kong Polytech University, Hong Kong
9	2	0.00	2022	King Abdulaziz University, Saudi Arabia
10	2	0.00	2021	Jaypee Institute Information Technology, India

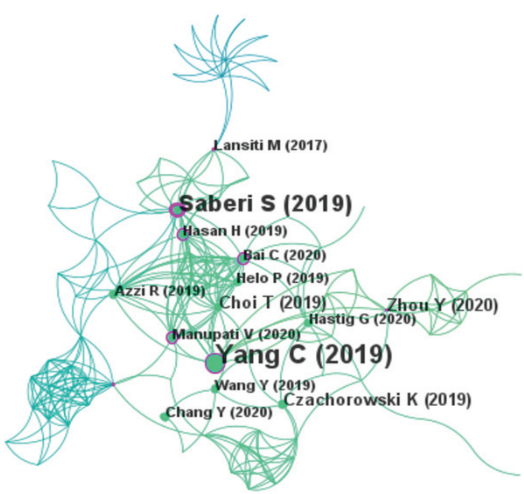
2. Co-citation Network Analysis

Co-citation is the frequency with which two documents are co-cited together by other documents. If two common documents are cited by at least one other document, these documents are called co-cited. The more the number of co-citations of two documents, the higher the co-citation strength and the higher the semantic relevance. That is, the two documents are considered more similar (Small, 1973). Therefore, this sector conducts the co-citation of references and authors for the sample articles.

1) Reference Co-citation Network

Reference co-citation analysis is a useful method to detect the structure and evolution path of a specific field by selecting some representative studies as the analysis object, and forming a reference co-citation network. The importance of the reference is generally analyzed in terms of its frequency of citations and centrality. It can be seen from Figure 4 that there are few connecting lines between nodes, which indicates that the co-cited reference is also minimal.

❙ Figure-4. References Co-citation Analysis ❙



The citation counts and centrality of specifically cited references are given in Table 3. As can be seen from these top 10 cited articles, the most cited articles were about blockchain applications or implementations in shipping or supply chain. In particular, the most cited article is the one by Yang (2019) with a total of 11 citations. A paper on blockchain technology and its relationships to sustainable supply chain management (Saberi et al., 2019) has the second-highest number of citations and has the greatest centrality (0.21). An article on the impact of blockchain on Singapore's maritime policy (Zhou et al., 2020) was cited four times, ranked third and the article had a centrality of over 0.1 indicating it was cited multiple times along with other articles. An overview of blockchain research in the maritime industry might be gained with the above articles.

Table-3. Details of Reference Co-citation

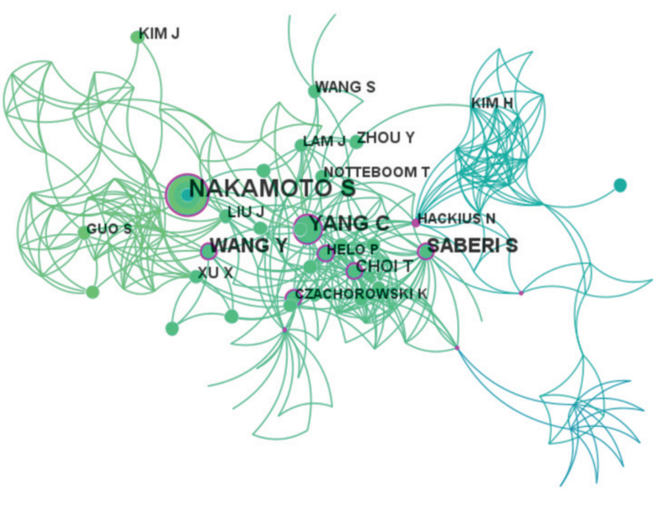
Rank	No.	Centrality	Year	Author	Title
1	11	0.18	2019	Chung-Shan Yang	Maritime shipping digitalization: Blockchain-based technology applications, future improvements, and intention to use
2	9	0.21	2019	Sara Saberi et al.	Blockchain technology and its relationships to sustainable supply chain management
3	4	0.14	2020	Yusheng Zhou et al.	The key challenges and critical success factors of blockchain implementation: Policy implications for Singapore's maritime industry
4	4	0.04	2.19	Karen Czachorowski et al.	The application of blockchain technology in the maritime industry
5	3	0.17	2017	Marco Lansiti et al.	The truth about blockchain
6	3	0.02	2019	Rita Azzi et al.	The power of a blockchain-based supply chain
7	3	0.00	2020	Sergey Tsiulin et al.	Blockchain-based applications in shipping and port management: a literature review towards defining key conceptual frameworks
8	3	0.06	2020	Gabriella M. Hastg et al.	Blockchain for Supply Chain Traceability: Business Requirements and Critical Success Factors

Rank	No.	Centrality	Year	Author	Title
9	3	0.19	2020	V.K.Manupati et al.	A blockchain-based approach for a multi-echelon sustainable supply chain
10	3	0.15	2019	Haya Hasan et al.	Smart contract-based approach for efficient shipment management

2) Author Co-citation Network

Author co-citation is a calculation of the frequency with which any work by an author is co-cited by other authors in the references of the cited documents (Jeong et al., 2014). Citation frequency is a form of peer recognition, which reflects the degree of trust and recognition of scholars by the academic community on the one hand, and the contribution and influence of scholars on the development of their disciplines on the other. It can even be said that highly cited authors make up the core of the scientific community of a specific domain. Regarding the analysis of the cited authors, only the first author is analyzed, because all publications of a specific author are merged into one (Fang et al., 2018).

▌Figure-5. Author Co-citation Analysis ▌



The author's co-citation network is presented in Figure 5. The top-cited author is Satoshi Nakamoto, with a citation count of 15, who published a white paper in 2008 called "Bitcoin: a peer-to-peer electronic cash system". The second most cited author is Yang (2019) who is the top author in the reference co-citation analysis. The third most cited author is Sara Saberi (2019) who is the second most cited author at the reference co-citation. In particular, the author with the highest centrality is Hackius et al. (2020), who has the thickest purple tree rings with a centrality value of 0.29. In any case, these authors listed in Table 4 have fundamental contributions to blockchain research in the maritime industry.

‖ Table-4. Details of Author Co-citation ‖

Rank	No.	Centrality	Year	Cited Author
1	15	0.11	2019	Satoshi Nakamato
2	11	0.17	2021	Chung-Shan Yang
3	9	0.18	2019	Sara Saberi
4	8	0.19	2019	Wang Yingli
5	6	0.14	2021	Tsan-Ming Choi
6	5	0.04	2021	Shuaian Wang
7	5	0.00	2021	Joon-Seok Kim
8	5	0.02	2021	Yusheng Zhou
9	5	0.05	2021	Xiwei Xu
10	5	0.08	2019	Jiaguo Liu

3. Keyword Co-occurrence Analysis

The keyword co-occurrence analysis is an attractive method for displaying emerging trends and tracking the evolution of research topics over time, as keywords provide an accurate and brief overview of a document. The evolution of research themes has evolved into an essential research question that enables researchers better to understand the dynamics of a specific subject area. CiteSpace-based keyword co-occurrence analysis mainly consists of two steps: first, extracting keywords, separating and classifying keywords, and calculating frequencies; second, obtaining the keyword co-occurrence matrix, which is used to analyze keyword co-occurrence. The following part identifies the hot spots and development trends of blockchain technology in the maritime industry through keyword co-occurrence analysis.

1) Timezone View

Table 5 illustrates the top 10 keywords in terms of count and centrality from 2017 to 2021, which shows the diversity of research topics. From the frequency of keyword appearances, the main hot research topics are as follows:

(1) Blockchain and its fundamental features: ‘blockchain’, ‘blockchain technology’, ‘smart contract’, ‘internet’ ‘internet of things’, and ‘technology’. These six keywords are related to the application of blockchain technology in the maritime industry and show that the development trend of the maritime industry needs blockchain technology as the foundation.

(2) Supply chain and its impact: ‘supply chain’, ‘logistics’, ‘model’, and ‘impact’. These four keywords can be summarized in the model or impact of supply chain or logistics.

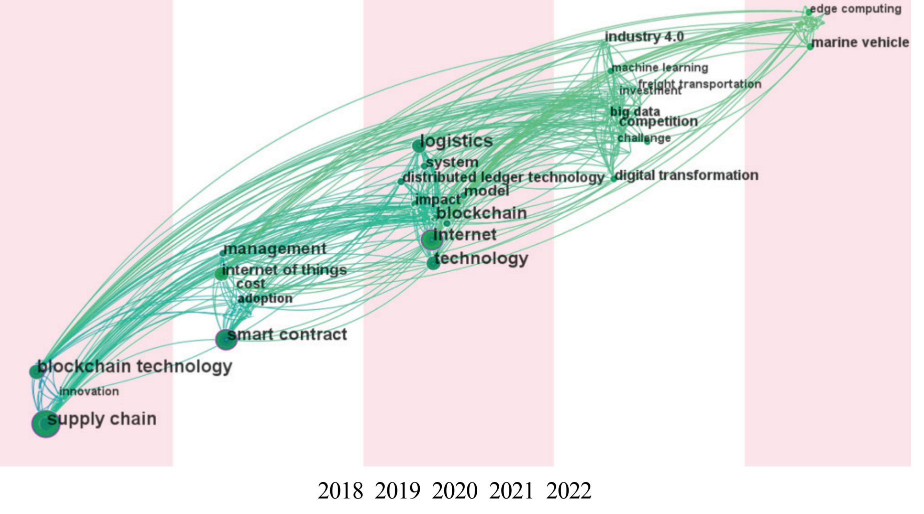
❙ Table-5. Top 10 Most Frequent Keywords ❙

Rank	No.	Centrality	Year	Keywords
1	20	0.37	2018	supply chain
2	13	0.24	2019	smart contract
3	12	0.34	2020	internet
4	9	0.32	2018	blockchain technology
5	9	0.15	2019	internet of things
6	9	0.16	2020	technology
7	8	0.20	2020	logistics
8	8	0.10	2020	model
9	6	0.14	2020	blockchain
10	6	0.02	2020	impact

The keywords are also taken as the analysis nodes to obtain the timing sequence of the ‘Timezone’ method in the visual layout. The visualization is arranged according to the time of publication or peak time of the keywords. The timezone view mapping is a collection of nodes simultaneously within the same time zone, and the time is arranged in order from far to near (Hongqiang et al., 2020). From Figure 6, it is observable that the keywords change each year from 2018 to 2022. The keyword appears in the year it first appeared, and subsequent studies are superimposed on the circle when it first appeared, so the circle size reflects the frequency in the studies on keywords throughout the whole period. Meanwhile, the purple tree rings illustrate the high centrality of the keyword; the thicker the purple circle, the stronger the centrality. The centrality is greater than 0.1, which indicates that these keywords connect different clusters and act as a bridge.

‘Blockchain technology’ and ‘supply chain’ were the earliest keywords to emerge in 2018, and the size of the node revealed that both keywords have been used in subsequent years as well. The year 2019 brought a higher level of betweenness centrality for ‘smart contracts’ and ‘internet of things’ with purple tree rings on the nodes. ‘Internet’, ‘technology’, ‘logistics’, ‘model’, ‘blockchain’, and ‘impact’ were keywords that emerged in 2020 and all of them have high betweenness centrality except for ‘impact’. Keywords that appear in 2020 focus on the high-tech, for example, ‘machine learning’, ‘big data’, and ‘digital transformation’, etc. Two hot words also appear in 2022, ‘edge computing’ and ‘marine vehicle’.

Figure-6. A Timezone View of Keywords



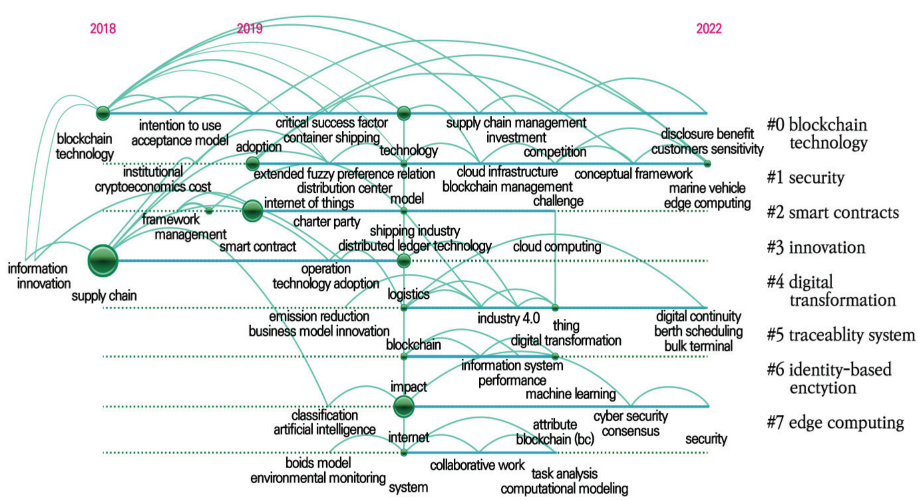
2) Timeline View

In order to completely comprehend the evolution process and display the studied knowledge clusters, a 'timeline' analysis of keywords in collections is visualized. The timeline visualization represents clusters through a horizontal timeline, with each cluster presented horizontally from left to right. Clusters are sorted vertically by size in declining order, with the largest cluster appearing at the top of the view (#0). The color curves depict the corresponding color to the same cited link added in the current year. The larger-sized nodes with purple tree rings either show a citation burst, are highly cited, or both (Chen, 2017).

The clustering analysis gets the evaluation index Q value of network modularity. The bigger the Q value, the more effective the network is in clustering. Q value higher than 0.3 indicates significant results. The average value of network homogeneity Silhouette, closer to 1, reflects the higher homogeneity of the network, and above 0.5 suggests that the clustering results are reasonable. Nodes indicate the use of citation chronology. Different colors and sizes of the chronology represent different years and the number of citations used to indicate the history of the literature being cited since its publication. After the clustering in this paper, the Modularity Q value is 0.5959, and the Weighted Mean Silhouette S equals 0.8598, which reveals that the graphical network clusters are better. The homogeneity is higher, and the clustering results are reasonable with a great reference value.

The number of keywords determines the ranking of clustering categories. The more keywords there are, the higher the ranking. The largest cluster of the silhouette score is usually a bit lower than that of the smaller clusters. As can be seen from Figure 7, the cluster ranked first (#0) is ‘blockchain technology’, containing ten-member keywords. The keywords ‘blockchain technology’ was first studied in 2018, and some clusters of research blockchains have been formed in the following years. The second cluster (#1) is processor scheduling and has nine members. The research started in 2019 with an ‘internet of things’ and formed a connection with other clusters of ‘things’ or ‘internet’. The third clustering (#2) is ‘smart contracts’ with seven members. The research on this category started with the keyword ‘smart contracts in 2019 and formed a series of studies eventually.

❙ Figure-7. A Timeline View of Keyword Clusters ❙



3) Strongest Citation Bursts

Citation explosion refers to papers with a sharp increase in the number of citations, which can partially reflect the dynamic changes (Chen and Liu, 2020). This section analyzes the data of the keywords in the sample papers, and Figure 8 lists the top 10 keywords, considering the high frequency and their strength with their corresponding red lines. The research trends and frontiers are shown as follows.

Since research on blockchain in the maritime industry began in 2018, 2019 burst into research hotspots with 'international trade', 'electronic transferable record', 'electronic bill of lading', and 'smart contract'. 'Logistics', 'shipping industry', and 'distributed ledger technology' became hotspots in 2020. In the following two years, 'model', 'Internet of Things', and 'digital transformation' became the new research hotspots and had been continuing.

Based on the above keyword emergent words and related research contents, there are different research trends in different periods, and the duration of the research hotspots is also different. Those words give an insight into the hotspots and trends of the year and their duration.

Figure-8. Top 10 keywords with the Strongest Citation Bursts

Keywords	Year	Strength	Begin	End	2018 - 2022
international trade	2018	1.13	**2019**	2019	
electronic transferable record	2018	1.13	**2019**	2019	
electronic bill of lading	2018	1.13	**2019**	2019	
smart contract	2018	1.08	**2019**	2019	
logistics	2018	1.33	**2020**	2020	
shipping industry	2018	1.28	**2020**	2020	
distributed ledger technology	2018	1.28	**2020**	2020	
model	2018	0.9	**2021**	2022	
thing	2018	0.86	**2021**	2022	
digital transformation	2018	0.86	**2021**	2022	

Ⅳ. Conclusions

1. Policy Implications

From the viewpoint of Korea, the policy implications which can be obtained through this study are summarized into two. The first is for the vitalization of blockchain-related research, while the second is about the advancement of the application of blockchain technology to the maritime industry.

As a result of collaboration network analysis and co-citation analysis of research literature, China is showing the world's best performance and influence in the field of blockchain research in the maritime sector. On the other hand, Korea ranks second in terms of publication number, however, there is no joint research performance with scholars from other countries. Most of the 9 blockchain-related studies are conducted through collaboration with domestic scholars, and it is interpreted that it is difficult to expect various synergies through joint research with foreign scholars.

At the same time, the fact that Korean universities or institutes were not included in the 10 research institutes that lead blockchain research in the maritime field shows that blockchain research in Korea is still on the periphery. The nationality of the 10 leading institutes includes 3 in China, 2 in Singapore, and 1 each in Hong Kong, India, Saudi Arabia, the United Arab Emirates, and Denmark. The research institutes in Greater China countries located in global shipping and logistics hubs show strength in research.

Considering the present situation, benchmarking of these research institutes is necessary, and policy support is needed so that knowledge sharing and creation can be achieved through cooperation with these institutes. For example, the establishment of a government-led research fund related to digital transformation in the maritime sector or the establishment of a specialized research center can be considered.

Next, implications related to the application of blockchain to the maritime industry are as follows. According to the three types of keyword co-occurrence analysis conducted in this study, the research topic started from a framework-level such as supply chain and blockchain technology in 2018, however, in 2019 it has developed into application fields such as international trade, electronic B/L, and smart contracts. Following this, it was identified that the main issues of blockchain research conducted in 2020 and 2021 focused on application models and impact analysis on the maritime industry. Over the past four years, research related to the application of blockchain technology in the maritime field has rapidly evolved into more detailed and specific issues, reflecting the need for practical industrial applications.

Research and industrial application generally represent a similar move, so if a specific country achieves high blockchain-related research results in the maritime sector, the application of blockchain to the maritime industry in that country can also be expected to be high. In the case of China, the “14th Five-year Policy” in 2021 presented blockchain as a core technology for the digital economy of national priority and announced an active fostering plan. According to the “2021 China Blockchain Industry Development White Paper”, there are more than 98 blockchain-related policies for finance, supply chain, logistics, internet, intellectual property rights, and public services between 2020 and 2021. Along with these policy achievements, it is known that China is building a blockchain platform led by the state. In 2019, President Xi Jinping declared that blockchain is a key technology for innovation and that China should seize the opportunities presented by blockchain technology. Accordingly, it appears that China recently completed a blockchain technology-based platform named Blockchain Service Network (BSN). It is natural that China, the world's largest trading power, will apply blockchain technology more actively to the maritime sector.

The Korean government is also recognizing the value of blockchain technology and is formulating related policies. In particular, the Korean government has declared an active nurturing plan for core technologies in the digital era, including blockchain, in the "Korean Version of the New Deal 2.0 Promotion Plan" in 2021. Both China and Korea were interested in the advancement of the application of blockchain technology and have prepared long-term development plans, but considering the overall market and economic size, it is likely that the results of the industrial application of blockchain technology will be realized first in China.

As a matter of fact, as seen in the current study, China and Korea are already exposing a large gap in terms of quantity and quality in research on blockchain applications in the maritime sector. In order for the Korean government not to lose its leadership in the future maritime industry, more active policy measures need to be prepared. For example, by establishing a blockchain technology support platform policy authorities might be able to find ways to share and spread blockchain-related technology and knowledge at a low cost in public and private sectors of the maritime industry.

2. Limitations

Despite the meaningful findings described above, this study has the following limitations. First, there are limitations related to data sources. The literature study generally chooses Google Scholar, Scoupe, Springer, PubMed, Web of Science database, etc. Since CiteSpace software analyzes data based on the Web of Science, data collected by other databases need to be converted. Therefore, the data in this paper are solely from the Web of Science Core Collection, which may not include the complete literature encompassing the subject matter. Future research should select the sample as comprehensively as possible. The second limitation relates to the application of the method. Regardless of the quantitative rigor of the bibliometric analysis, clarifying the content of co-citation graphs and tables is not a straightforward process. This paper provides solely a descriptive and keyword co-occurrence analysis of the basic features of the samples using Citespace software. It could not fully describe the characteristics that these samples are intended to exhibit. Therefore, the samples need to be described and analyzed and combined with other methods. The third limitation concerns literature development. The development of blockchain technology in the maritime industry has been continuing, and the description and summary of this paper provide some reference value. Different results can be obtained from different time dimensions and data samples. Therefore, the analysis results in this paper may only have temporary applicability. More studies are necessary for the future if a more profound understanding is required.

투고일 2022. 04. 28
1차 심사일 2022. 05. 13
게재확정일 2022. 06. 13

Reference

1. Ahluwalia, Saurabh, Raj V. Mahto, and Maribel Guerrero. 2020. “Blockchain Technology and Startup Financing: A Transaction Cost Economics Perspective.” Technological Forecasting and Social Change, Vol. 151, pp. 119854.
2. Azzi, Rita, Rima Kilany Chamoun, and Maria Sokhn. 2019. “The Power of a Blockchain Based Supply Chain.” Computers & Industrial Engineering, Vol. 135, pp. 582–92.
3. Brophy, Richard. 2019. “Blockchain and Insurance: A Review for Operations and Regulation.” Journal of Financial Regulation and Compliance, Vol. 28, No. 2, pp. 215–34.
4. Capó-Vicedo, Josep, Josefa Mula, and Jordi Capó. 2011. “A Social Network-based Organizational Model for Improving Knowledge Management in Supply Chains.” Supply Chain Management: An International Journal, Vol. 16, No. 4, pp. 284–93.
5. Chen, Chaomei. 2017. “Science Mapping: A Systematic Review of the Literature.” Journal of Data and Information Science, Vol. 2, No. 2, pp. 1–40.
6. Chen, Chaomei, Fidelia Ibekwe-SanJuan, and Jianhua Hou. 2010. “The Structure and Dynamics of Cocitation Clusters: A Multiple-Perspective Cocitation Analysis.” Journal of the American Society for Information Science and Technology, Vol. 61, No. 7, pp. 1386–1409.
7. Chen, Chaomei, and Min Song. 2019. “Visualizing a Field of Research: A Methodology of Systematic Scientometric Reviews” edited by W. Glanzel. PLOS ONE, Vol. 14, No. 10, pp. e0223994.
8. Chen, Xiaoyan, and Yisheng Liu. 2020. “Visualization Analysis of High-Speed Railway Research Based on CiteSpace.” Transport Policy, Vol. 85, pp. 1–17.
9. Criscuolo, Paola, Ammon Salter, and Tony Sheehan. 2007. “Making Knowledge Visible: Using Expert Yellow Pages to Map Capabilities in Professional Services Firms.” Research Policy, Vol. 36, No. 10, pp. 1603–19.
10. Czachorowski, Karen, Marina Solesvik, and Yuriy Kondratenko. 2019. “The

Application of Blockchain Technology in the Maritime Industry." In Studies in Systems, Decision and Control, 561–77. Springer.

11. Fang, Yan, Jie Yin, and Bihu Wu. 2018. "Climate Change and Tourism: A Scientometric Analysis Using CiteSpace." Journal of Sustainable Tourism, Vol. 26, No. 1, pp. 108–26.
12. Hackius, Niels, and Moritz Petersen. 2020. "Translating High Hopes Into Tangible Benefits: How Incumbents in Supply Chain and Logistics Approach Blockchain." IEEE Access, Vol. 8, pp. 34993–3.
13. Hasan, Haya, Esra AlHadhrami, Alia AlDhaheri, Khaled Salah, and Raja Jayaraman. 2019. "Smart Contract-Based Approach for Efficient Shipment Management." Computers & Industrial Engineering, Vol. 136, pp. 149–59.
14. Hastig, Gabriella M., and ManMohan S. Sodhi. 2020. "Blockchain for Supply Chain Traceability: Business Requirements and Critical Success Factors." Production and Operations Management, Vol. 29, No. 4, pp. 935–54.
15. Hongqiang, Ma, Chen Hongyu, Hou Jinliang, Ge Jieya, and Lv Wei. 2020. "CiteSpace-Based Visualization Analysis on Mappings of Alkali-Activated Cementitious Materials in the Field of Engineering Research." Case Studies in Construction Materials, Vol. 12, pp. e00350.
16. Jain, Geetika, Harjit Singh, K R Chaturvedi, and Sapna Rakesh. 2020. "Blockchain in Logistics Industry: In Fizz Customer Trust or Not." Journal of Enterprise Information Management, Vol. 33, No. 3, pp. 541–58.
17. Jhang, Se-Eun and Su-Ho Lee. 2016. "A Study of Themes and Trends in Research of Global Maritime Economics through Keyword Network Analysis." Journal of Korea Port Economic Association, Vol. 32, No. 1, pp. 79–95. (In Korean)
18. Jeong, Yoo Kyung, Min Song, and Ying Ding. 2014. "Content-Based Author Co-Citation Analysis." Journal of Informetrics, Vol. 8, No. 1, pp. 197–211.
19. Jugović, Alen, Juraj Bukša, Alex Dragoslavić, and David Sopta. 2019. "The Possibilities of Applying Blockchain Technology in Shipping." Scientific Journal of Maritime Research, Vol. 33, No. 2, pp. 274–79.17.

20. Kazakzeh, Saif, Eyad Ayoubi, Baraa K Muslmani, Malik Qasaimeh, and Mustafa Al-Fayoumi. 2019. “Framework for Blockchain Deployment: The Case of Educational Systems.” In 2019 2nd International Conference on New Trends in Computing Sciences (ICTCS), 1–9. Pricess Sumaya University for Technology, Amman, Jordan: IEEE.

21. Lansiti, Marco, and Karim Lakhani. 2017. “The Truth About Blockchain.” Harward Business Review, Vol. 95, No. 1, pp. 118–27.

22. Li, Xinjian, Emily Ma, and Hailin Qu. 2017. “Knowledge Mapping of Hospitality Research ― A Visual Analysis Using CiteSpace.” International Journal of Hospitality Management, Vol. 60, pp. 77–93.

23. Manupati, V K, Tobias Schoenherr, M Ramkumar, Stephan M Wagner, Sai Krishna Pabba, and R. Inder Raj Singh. 2020. “A Blockchain-Based Approach for a MultiEchelon Sustainable Supply Chain.” International Journal of Production Research, Vol. 58, No. 7, pp. 2222–41.

24. Nimsai, Suthep, Chanin Yoopetch, and Polin Lai. 2020. “Mapping the Knowledge Base of Sustainable Supply Chain Management: A Bibliometric Literature Review.” Sustainability, Vol. 12, No. 18, pp. 7348.

25. Papathanasiou, Angeliki, Rosanna Cole, and Philip Murray. 2020. “The (Non-) Application of Blockchain Technology in the Greek Shipping Industry.” European Management Journal, Vol. 38, No. 6, pp. 927–38.

26. Saberi, Sara, Mahtab Kouhizadeh, Joseph Sarkis, and Lejia Shen. 2019. “Blockchain Technology and Its Relationships to Sustainable Supply Chain Management.” International Journal of Production Research, Vol. 57, No. 7, pp. 2117–35.

27. Small, Henry. 1973. “Co-Citation in the Scientific Literature: A New Measure of the Relationship between Two Documents.” Journal of the American Society for Information Science, Vol. 24, No. 4, pp. 265–69.

28. Tsiulin, Sergey, Kristian Hegner Reinau, Olli-Pekka Hilmola, Nikolay Goryaev, and Ahmed Karam. 2020. “Blockchain-Based Applications in Shipping and Port Management: A Literature Review towards Defining Key Conceptual Frameworks.”

Review of International Business and Strategy, Vol. 30, No. 2, pp. 201–24.

29. Wang, Xuefeng, Rongrong Li, Shiming Ren, Donghua Zhu, Meng Huang, and Pengjun Qiu. 2014. "Collaboration Network and Pattern Analysis: Case Study of Dye-Sensitized Solar Cells." Scientometrics, Vol. 98, No. 3, pp. 1745–62.

30. Yang, Chung-Shan. 2019. "Maritime Shipping Digitalization: Blockchain- Based Technology Applications, Future Improvements, and Intention to Use." Transportation Research Part E: Logistics and Transportation Review, Vol. 131, pp. 108–17.

31. Zhou, Yusheng, Ying Shan Soh, Hui Shan Loh, and Kum Fai Yuen. 2020. "The Key Challenges and Critical Success Factors of Blockchain Implementation: Policy Implications for Singapore's Maritime Industry." Marine Policy, Vol. 122.

32. Zubaydi, Haider Dhia, Yung-Wey Chong, Kwangman Ko, Sabri M. Hanshi, and Shankar Karuppayah. 2019. "A Review on the Role of Blockchain Technology in the Healthcare Domain." Electronics, Vol. 8, No. 6, pp. 679.