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Review of studies of blockchain technology effects on the shipping industry

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Abstract

Decision-making is a prolific research area in the internet era, which has propelled globalization and the virtual elimination of many country border barriers. However, effective decision-making in the shipping industry is a time consuming and often complicated process. Digital evolution has provided new innovative organizational operation methods. Blockchain technology—a basic component of the Fourth Industrial Revolution—is one such innovation that promises to alter the process of decision-making. However, only a few academic studies have explored the decision-making aspect of blockchain technology. Moreover, there is a dearth of comprehensive research on how blockchain affects decisions in the shipping industry. This study explored how this novice technology can address issues, such as vast documentation and information asymmetry in the shipping industry. Specifically, grounded theory was used to qualitatively investigate extant practices and examine the potential impact of blockchain technology on decision-making in the shipping industry and the potential of using blockchain technology to emancipate decision-making. The study results indicate that the instant and reliable data-sharing capability of blockchain can significantly impact the shipping industry, while transforming its decision-making processes.

Keywords: Blockchain, Decision-making, Grounded theory, Knowledge transfer, Shipping

Introduction

The globalization era has introduced novel trading paradigms and has increased the demand for new approaches to production and distribution that, in turn, might alter shipping operation standards forever (Lambrou et al. 2019). The complementary development of digital technologies offers innovations to many competitive industries, including shipping (Kaygın et al. 2018). It is particularly necessary to highlight the specific needs of the shipping industry regarding information management so that innovation can be pursued. The shipping industry has been the basic pillar of international trade (Filom and Van Hassel 2020) and a main component of globalization (Jović et al. 2019) for centuries.

The maritime sector operates using an information network that involves many parties, e.g., shippers, freight forwarders, and carriers (Jabbar and Bjørn 2018). Specifically, extant operation systems in the industry are characterized by bureaucracy,

centralization, lack of bias, and information asymmetry (Di Vaio and Varriale 2020). Information asymmetry is a complication caused by intermediate participants in the operating process (Filom and Van Hassel 2020), considering that shipping industry systems are closely related to other integrated transportation systems (Jović et al. 2019). More precisely, maritime operations involve complex procedures that require the interaction of numerous stakeholders (Jović et al. 2019). Additionally, many rules and regulations govern the industry, making transactions rigid, complex, and expensive both temporally and financially (Jain 2018).

The shipping industry involves the exchange of vast amounts of information within its global supply chain network (Jović et al. 2019). Existing works have highlighted the importance of knowledge transfer and its potential to reduce uncertainty (Massaro et al. 2019), while generating new knowledge (Kang et al. 2010). Accordingly, knowledge transfer can positively contribute to effective decision-making as part of the knowledge-management process. Effective communication is a key element of effective knowledge transfer (Demeter and Losonci 2019). Thus, it is a compelling opportunity to pose a research question regarding how blockchain technology might support the dissemination of knowledge and enhance maritime operational decision-making. Specifically, the research question is addressed by reviewing and summarizing prior studies on the effect of the new blockchain technology on the shipping industry.

Consequently, the research scope is connected to the utilization of blockchain technology in the supply chain process of the shipping industry and its potential to improve information dissemination and enhance decision-making (Filom and Van Hassel 2020). This research addresses a gap in the extant literature of blockchain technology. Currently, research focusing on the applications of this novel digital technology is scarce. However, blockchain is vital to the innovative and secure distribution of knowledge and information, which, if optimized for maritime logistics, will ameliorate the management of documentation in the maritime industry and support more efficient and effective decisions (Pu and Lam 2021; Zhong et al. 2021). To the best of the researcher's knowledge, only a few existing studies have combined the fields of blockchain technology and the decision-making process in the shipping sector. Several papers have discussed and analyzed the application of blockchain in the context of digitalizing shipping transactions (i.e., the use of smart contracts) and establishing digital ports or the advent of smart ships (Jović et al. 2019). However, thus far, the application of novel information technologies with respect to decision-making in the shipping industry has not been examined. The present study aims to fill this gap by summarizing the existing literature and determining how the application of blockchain technology in shipping documentation and transactions can support the distribution of knowledge and facilitate maritime operational decision-making.

Information resources and blockchain technology

Types of information resources

Knowledge and information are derived from several channels and sources (Byström and Järvelin 1995), which are categorized using many parameters, e.g., presence or absence of individual interaction and origination from within or outside an organization (Byström and Järvelin 1995). Similarly, Van den Boer et al. (2016) cataloged

distinguished knowledge and information resources into categories of personal (e.g., face-to-face or telephone), formal (e.g., written), and informal/electronic (e.g., internet, email, and datasets). Jones et al. (1988) focused more on the form of knowledge and its source to make distinctions in terms of whether a source is personal or impersonal, and based on whether it is written or verbal. Zimmer et al. (2007) focused on individual interactions and suggested a more general categorization of knowledge and information resources: relational and non-relational. Relational resources originate from individuals inside and outside an organization, whereas non-relational ones refer to written information or knowledge not involving physical interactions. These include written, online, and company data sources (Zimmer et al. 2007). In the present digital era, most literature embodies electronic forms of information/knowledge. In this context, Kim et al. (2016) noted that information could be found on computers, printed documents, and social sources.

The literature reveals that some types of information sources are preferred over others. Lin et al. (2014) assessed the use of information resources for strategic decision-making considering five criteria: relevance, comprehensiveness, reliability, time/effort, and accessibility. Reliability is considered to be a very important criterion when choosing information resources, with relevance and accessibility also being critical (Lin et al. 2014). Zimmer et al. (2007) argued that resource accessibility and quality were generally essential values for knowledge/information researchers. Moreover, Zimmer et al. (2007) noted that managers tend to disregard the quality of a knowledge/information source in favor of its accessibility.

Use of past experience and data for decision-making

Organizational decision-making is often influenced by past cases. Mishra et al. (2015) noted the reliance of managers on past experience when making decisions to minimize uncertainty and overcome time constraints. However, understanding that the present case differs from previous ones can alter the intuitive mode of decision-making, making it more analytical and evidence-based (Mishra et al. 2015). Consequently, managers should update their knowledge and decision-making assumptions through evidence (Vlajcic et al. 2019).

Decision-making based on the analysis of real-time data is indeed significant for companies (García-Magariño et al. 2020). However, the management of big data is not an easy task for the shipping industry (Perera and Czachorowski 2019). It is hindered by the integration of information and a lack of transparency (Jain 2018). Decision-making is largely the responsibility of company directors (Lafarre and Van der Elst 2018), and until now, managers have simultaneously been the beneficiaries and bearers of the privilege and burden of information access and strategic decision-making (Van Rijmenam et al. 2018). Although this restricted privilege has political value (McCook 2018), it complicates execution and results in agency problems (Lafarre and Van der Elst 2018).

Blockchain technology in decision-making

Decision-making is being increasingly supported by artificial intelligence and autonomous systems (Calvaresi et al. 2019). A decentralized system (e.g., blockchain) helps to address agency and coordination problems by offering flexibility when sharing

information (Perera and Czachorowski 2019). It enables decentralized, fast, and transparent sharing, solves problems of communication inadequacy, and makes decision-making simpler and quicker (Lafarre and Van der Elst 2018; Tsiulin et al. 2020).

Decisions based on blockchain technology are also executed much faster than conventional approaches (McCook 2018). For example, the use of smart contracts offers an automated mode of decision-making based on predetermined parameters agreed upon by actors (Van Rijmenam et al. 2018). Accordingly, shipping industry players are increasingly becoming convinced of the effectiveness of collaboration and collective decision-making for their sustained growth (Diordiiev 2018). Nevertheless, cooperation among parties involved in shipping transactions remains complex (Jain 2018), and extensive collaboration often encounters difficulties regarding issues of privacy, security, and confidence (Yang et al. 2019). Currently, some innovative collaborative decision-making methods are being used by industry participants (Van Rijmenam et al. 2018). Collaborative decision-making refers to a decision-making process involving the cooperation of different parties having diverse knowledge and expertise for optimized benefits (Yang et al. 2019). In this context, new digital technologies may transform decision-making into a procedure characterized by synergy instead of authority (Yang et al. 2019; Van Rijmenam et al. 2018). Consequently, blockchain technology offers entirely new routes and perspectives on decision-making (Lafarre and Van der Elst 2018).

Blockchain was first introduced in 2008 in connection with the "Bitcoin" digital cryptocurrency (Randall et al. 2017). The first blockchain technology application was introduced by Nakamoto (2008). Bitcoin is an important part of innovative technology (Wörner et al. 2016), and it enables rapid transactions, smart contracts, and reliable tracking (Wang and Qu 2019). It is a distributed and decentralized digital ledger of data (Jović et al. 2019) that permanently stores all transactions. Blockchain has two main components: a block and chain. The block includes the transactions, and the chain comprises the links between them (Jović et al. 2019). With blockchain technology, a transaction may refer to a value transfer or an information exchange (Green et al. 2020). With the application of smart contracts, blockchain technology eliminates unnecessary negotiations (Jugović et al. 2019). Smart contracts are activated via mutual consent among the involved parties (Ølnes et al. 2017). A consensus algorithm is always used to approve transactions in a blockchain system, making the technology a safe means of decision-making (Yang et al. 2019).

A blockchain system is a data dissemination network that functions on a peer-to-peer basis (Jović et al. 2019). Information redundancy is the essence of blockchain technology (Si et al. 2019), and participants unknown to one another can create and share a common digital ledger of data for transaction verification (Jović et al. 2019). The technology provides a type of democratic means of information sharing, considering that all parties involved may have equal access to relevant information (Esmaeilzadeh and Mirzaei 2019).

Blockchain technology has the ability to transform society and economy (Grover et al. 2019). It has, in fact, been noted that the transportation industry can benefit from blockchain technology (Grover et al. 2019). Specifically, the technology can improve shipping operations by introducing many innovations (Jović et al. 2019). The

main advantage of blockchain is related to its utility for disseminating reliable data to different parties, thus contributing to decreasing operation costs and improving collaboration (Bai et al. 2020).

Role of blockchain in the shipping industry

Information asymmetry is a noteworthy problem in the shipping industry, partly because the generated information is often used by different parties (Mattila et al. 2016). However, some parties do not create useful data, resulting in information gaps (Mattila et al. 2016). Blockchain technology helps shipping industry third parties, such as banks, freight forwarders, and agents, overcome this problem (Jugović et al. 2019). Data cannot be edited or deleted from a blockchain, and they are secure and independent of any single computer node. Thus, the need for administration is eliminated (Jain 2018). The initial purpose of blockchain technology was to provide confidential information on financial transactions without interference from third parties (Jović et al. 2019). The fact that a blockchain eradicates the role of third parties makes the technology comparable to and compatible with the internet (Van Rijmenam et al. 2018). In this respect, blockchain technology may contribute to the so-called emancipation of organizations (Mattila et al. 2016).

Overall, the utilization of effective technologies to reduce the required documentation would be extremely beneficial to the maritime sector (Jain 2018). However, this sector has been conservative in regard to the adoption of innovative technologies (Filom and Van Hassel 2020), leading to complications (Green et al. 2020). Consequently, the application of blockchain technology to the shipping industry remains a challenge (Jabbar and Bjørn 2018). Thus far, the technology has not been widely adopted in shipping operations (Diordiiev 2018).

It should be emphasized that the shipping industry, although a conservative sector, has successfully adopted new technologies in the past (Jugović et al. 2019) with the first fully automated ocean-going vessel anticipated to be in operation by 2030 (Diordiiev 2018). High-technology vessels are equipped with modern systems that use the Internet of Things, a technology that can be used in conjunction with blockchain to store and disseminate data (Green et al. 2020). Moreover, considering that shipping operations currently do not often include innovative elements, the maritime industry is fertile ground for the application of digital-technology systems, e.g., smart vessels, fleets, and global logistics (Jović et al. 2019), as well as the transformative application of blockchain technology (Jugović et al. 2019). The objective of this study, therefore, is to examine whether blockchain can significantly facilitate decision-making in the shipping industry and make shipping operations less complex.

Research methodology

The research data were analyzed based on a qualitative paradigm with grounded theory to explore the significance of blockchain technology to decision-making (Junusi 2020). The academic manuscripts were cited using the Google Scholar platform (Martín-Martín et al. 2021). The keywords used for the Google Scholar search included "Blockchain," "Shipping," "Maritime," and "Decision-making." Thus, all academic papers relevant to the search keywords between the years of 2018 and 2021 were included in the analysis of

this research (Martín-Martín et al. 2021). Specifically, the full text of 38 academic papers was analyzed, including recent works on blockchain technology, decision-making, and the shipping industry.

Grounded theory was used to interpret industry phenomena in a subjective manner (Sciberras and Silva 2018). This research method can be applied through both qualitative and quantitative methods with a focus on creating a data-based theory (Chun Tie et al. 2019). Considering the interest in managerial phenomena, the basic theory was constructed by processing data from the existing literature, instead of assessing extant theories (Miller et al. 2019). Consequently, the grounded theory method was applied in the context of a qualitative paradigm for analyzing a collection of academic articles indexed in Google Scholar, enabling the identification of induced patterns (Sciberras and Silva 2018). The analysis of the academic articles in the present study was conducted using initial and focused coding via MAXQDA version 2020 (Turedi and Ozer-Caylan 2021). MAXQDA software is a useful tool for qualitative analysis that permits the generation of concepts from codes (Iyer et al. 2021). Effectively, MAXQDA enables the gradual creation of thematic categories that contribute to the creation of a theoretical framework (Jacques 2021).

The analysis first involved creating links between ideas in the text data through deduction. This was used to code the text data for thematic classification with the objective of generating a new theory from the extant literature (Turedi and Ozer-Caylan 2021). The use of memo notes facilitated the open coding process. Thus, several thematic categories were pinpointed, contributing to the initial theory building (Turedi and Ozer-Caylan 2021). Following the identification of the initial codes, the research input was further examined to identify analogies and connections among the themes (Sciberras and Silva 2018). After analyzing the first two academic papers, memo notes were generated for better segmentation of the thematic categories (Turedi and Ozer-Caylan 2021).

The primary thematic codes facilitated the continuous comparison of the collected data and distinguishing of the relevant subcodes (Sciberras and Silva 2018). This iterative comparison simultaneously contributed to better codifying of the text data and the development of categories, resulting in the generation of theories via induction (Sciberras and Silva 2018). This research utilized axial codification to determine the interrelation of the themes and their subthemes (Turedi and Ozer-Caylan 2021), and further selective coding was used to reorganize the data and generate meaningful theories related to the identified categories (Snodgrass et al. 2020). This process was continued until no further relations among the basic codes/ideas could be distinguished (Turedi and Ozer-Caylan 2021).

Thus, the initial categorization of the literature was performed considering the initial concepts and thematic classifications (i.e., shipping industry, decision-making, and blockchain technology), which were identified in the full text of 38 academic papers explored during this research. Then, open coding was concluded, in which two broad codes were created: "shipping industry and decision-making" and "blockchain effects on decision-making" (Fig. 1). Subsequently, during the initial coding stage, more subcodes were generated for each open code (e.g., the subcode "shipping industry traits" for the code "shipping industry and decision-making"), according to the identified themes. Finally, the axial coding involved the creation of subcodes to the initial codes (e.g., the

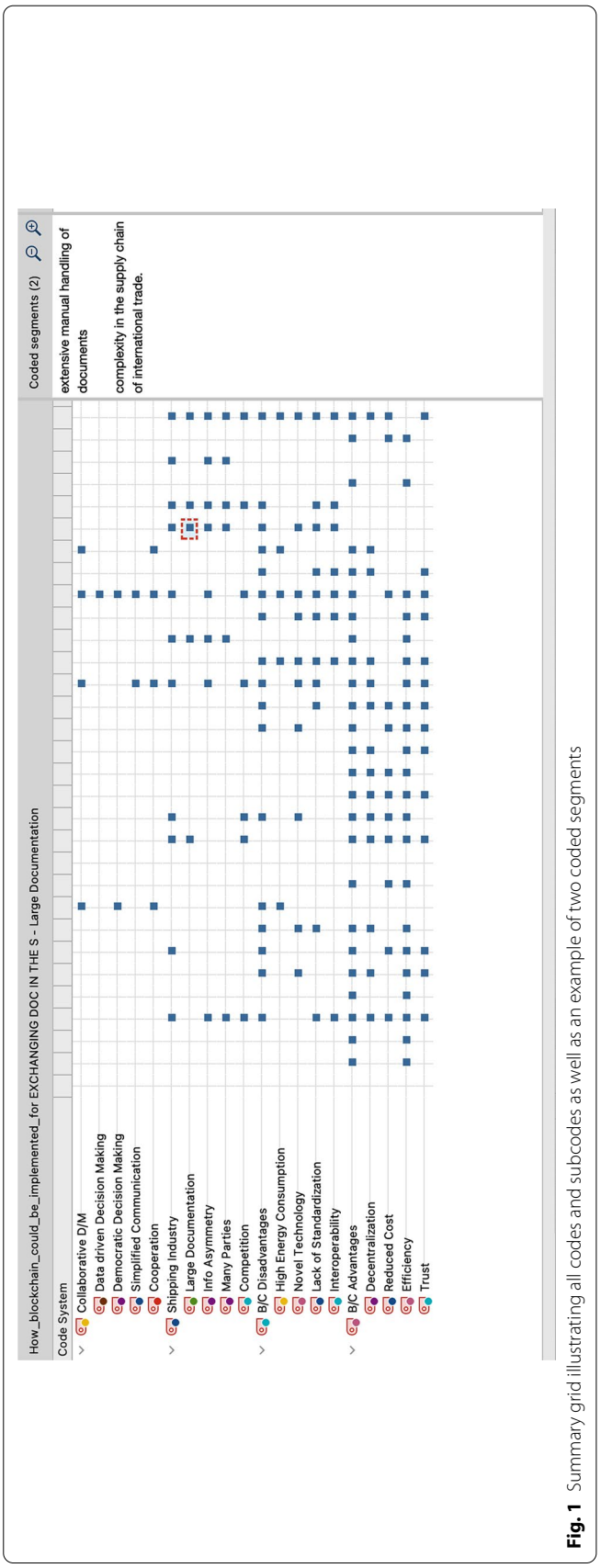

Fig. 1 Summary grid illustrating all codes and subcodes as well as an example of two coded segments

subcode "information asymmetry" for the initial subcode "shipping industry traits"). This procedure was continued until the saturation point was reached.

A summary grid (Fig. 1) was created, illustrating all final codes and subcodes related to the academic articles analyzed in this research. This figure presents an example of two coded segments from one of the analyzed academic papers, which were classified in the "large documentation" subcode, part of the "shipping industry" code.

Results

Most important keywords in the data

Complementing the existing literature on blockchain technology, the initial findings were derived from the cloud visualization of the top-50 words of all documents involved in this research (Fig. 2). In total, 38 academic articles were analyzed, comprising 162,396 words. The words displayed in larger size are considered to be of higher significance. Specifically, the results of the word cloud of the top-50 words demonstrate a connection between the innovative "blockchain technology" and the creation of a "smart" and "secure" "network" for "information" "exchange," which may be applied to the "shipping" industry to "share" and "distribute" data (Fig. 2).

Furthermore, the frequencies of the top-25 words (Table 1) in the research documents were computed to better interpret the role that the new blockchain technology may play in the decision-making process in the shipping industry. In this respect, the findings suggest that "network" and "information" are significant terms, showing the highest frequency after the terms "blockchain" and "technology." In addition, the terms "exchange," "access," and "share" occupy positions 12, 13, and 18, respectively. Consequently, we can suggest that these three words, having a similar meaning, are related to the effective dissemination of information, and thus, may contribute to more successful "decisions" and "management" in the "shipping" industry. In other words, the findings imply that the new blockchain technology may play a catalytic role in facilitating the transfer of data in the shipping industry business.

Characteristics of shipping decision-making

Following the identification of the most important keywords in the text data, the results referring to the traits of the decision-making process in the shipping industry are presented. The shipping industry is not only competitive, but it can also be regarded as technology- and information-intensive (Filom and Van Hassel 2020). However, the industry is characterized by several inefficiencies in its operations and execution of transactions. The research results (Fig. 3) indicate that there is a requirement for a large amount of documentation, and the processes are rather rigid and complex (Di Vaio and Varriale 2020). Specifically, decision-making in the shipping industry often involves the processing of a large amount of information and data (Di Vaio and Varriale 2020). This is confirmed by the results of the present study in Fig. 3, showing that the paperwork can be excessive (Filom and Van Hassel 2020). Additionally, decision-making involves numerous parties and stakeholders, with information asymmetry often present (Jović et al. 2019). This results in a complex, multistage process that is often characterized by communication problems, lack of cooperation (Demeter and Losonci 2019), high costs,

Fig. 2 Word cloud of the top-50 words in the analyzed academic articles

Table 1 Frequencies of top-25 words in the text data

Word	Word length	Frequency	%	Rank	Documents	Documents %
Blockchain	10	3111	1.99	1	36	94.74
Technology	10	1432	0.92	2	37	97.37
Information	11	1226	0.78	3	36	94.74
Network	7	1007	0.64	4	31	81.58
Industry	8	617	0.39	5	29	76.32
System	6	579	0.37	6	33	86.84
Business	8	572	0.37	7	32	84.21
Time	4	558	0.36	8	32	84.21
Chain	5	551	0.35	9	32	84.21
Process	7	521	0.33	10	30	78.95
Management	10	516	0.33	11	28	73.68
Exchange	8	455	0.29	12	25	65.79
Access	6	431	0.28	13	30	78.95
Ship	4	431	0.28	13	23	60.53
Smart	5	430	0.28	15	29	76.32
Contract	8	425	0.27	16	28	73.68
New	3	417	0.27	17	31	81.58
Share	5	416	0.27	18	35	92.11
Service	7	408	0.26	19	28	73.68
Block	5	399	0.26	20	24	63.16
Model	5	398	0.25	21	32	84.21
Platform	8	385	0.25	22	26	68.42
Decision	8	368	0.24	23	25	65.79
Provide	7	363	0.23	24	34	89.47
Company	7	354	0.23	25	26	68.42

delays, and low efficiency (Jain 2018). This suggests that the shipping industry can benefit from innovations such as blockchain technology (Jović et al. 2019).

Advantages of blockchain technology

Figure 4 suggests that blockchain might present a radical solution to the above-mentioned challenges faced by decision-makers, and it promises to be applicable to many industries (Huhmo 2018). The technology has the potential to transform the global economy (Diordiiev 2018) and is currently influential in several industries and societies (Ølnes et al. 2017), offering the advantages of decentralization (Randall et al. 2017), fast acquisition, storage, and dissemination of information (Nga et al. 2020).

Table 2 depicts examples of the context of the keyword "blockchain" in the research documents, focusing on some of the advantages of blockchain technology (i.e., "blockchain technology will help shipping"). It shows that time saving and the accurate provision of information would be particularly beneficial to the competitive shipping industry (Jugović et al. 2019). With its application, a single digital ledger could solve the problem of collecting, storing, and analyzing all the data available in the shipping industry (Jugović et al. 2019). Ocean carriers would benefit the most from the technology through instant sharing of data that would enhance the entire supply chain (Nga et al. 2020). Stakeholders would have instant and secure information about shipping operations (Jain

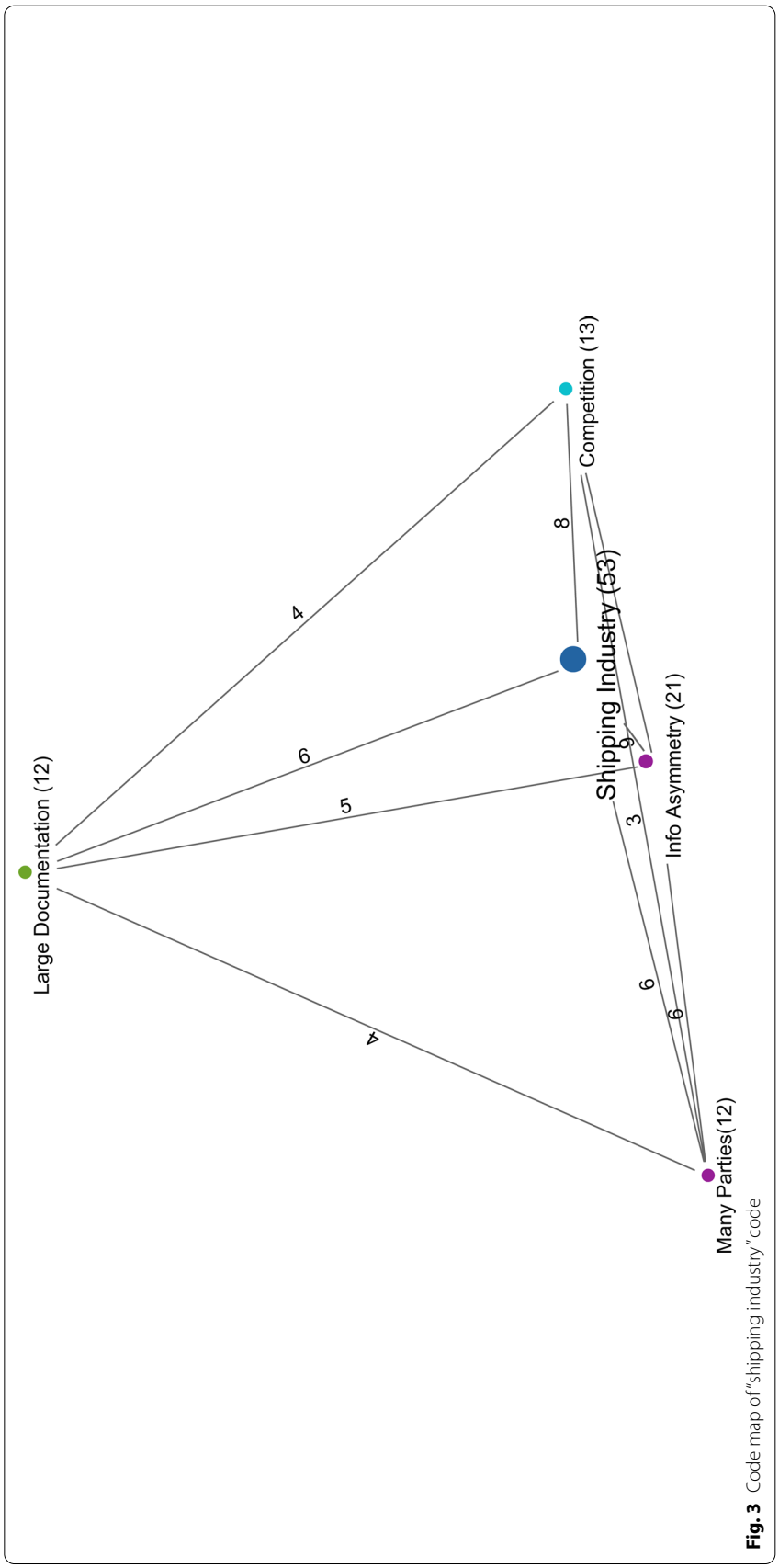

Fig. 3 Code map of "shipping industry" code

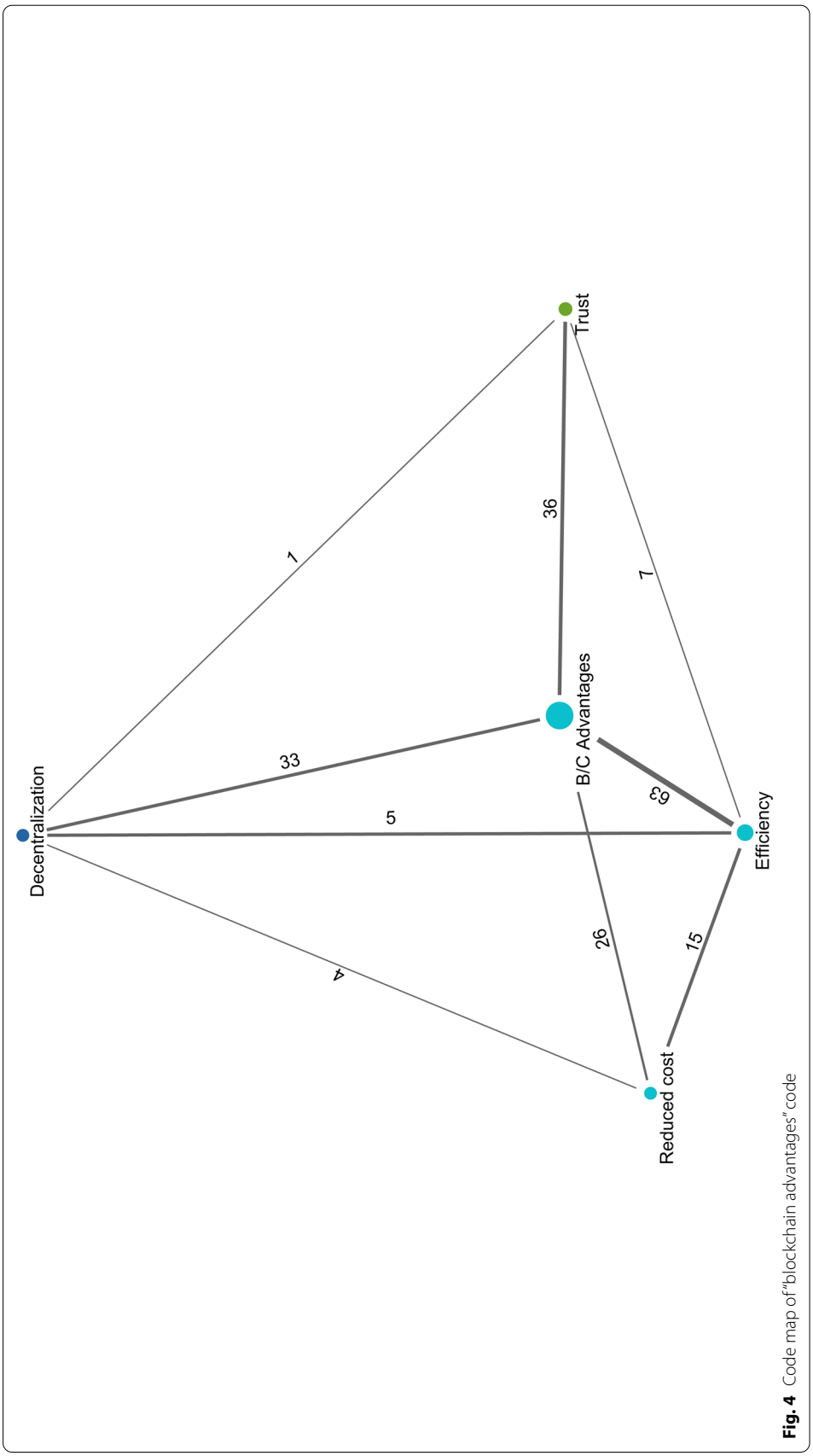

Fig. 4 Code map of "blockchain advantages" code

Table 2 Examples of the "blockchain" keyword in context

Beginning	Context	Keyword	Context
5:2065	The smart contract functionality	Blockchain	Technology can add an appropriate
5:2501	Time, the structure of the	Blockchain	i.e., decentralized information storing
8:4159	Services is another industry where	Blockchain	Technology will help shipping
8:4685	Information will be stored on	Blockchain	Each party involved will have
9:1143	All the information on the	Blockchain	Will be encrypted, its exchange

2018). In the financial industry, the cost reduction achieved by blockchain technology is expected to reach 15–20 billion USD in the next two years (Randall et al. 2017) (Fig. 4).

As illustrated in Table 2 and Fig. 4, blockchain technology also enables the possibility of exchanging information based on trust and transparency (Loklindt et al. 2018), relying on consensus and cryptography to prevent fraud (Jović et al. 2019). It is distinguished by objectivity and trust, and thus, competes with even the most trustworthy industry participants (Beck et al. 2017). Furthermore, it fosters a sense of trust in the sharing of information, resulting in faster, cheaper, and easier business transactions (Huhmo 2018).

The study results in Fig. 4 and Table 2 also demonstrate that blockchain technology supports collaboration in decision-making (i.e., "decentralized information"). Moreover, the notion of collaborative decision-making is related to trust and transparency in transactions (Diordiiev 2018). Additionally, the findings imply that collaborative decision-making reduces the time and cost of making decisions (Jain 2018). Thus, blockchain technology may contribute to achieving simplified, effective, and data-driven decision-making in the shipping industry (Jain 2018). The process would involve fewer parties, while also being more democratic and emancipating, on the basis that all parties involved may have equal access to the relevant information (Yang et al. 2019).

Problems of blockchain technology

Figure 5 presents some drawbacks of the new digital technology. With regard to the problems associated with blockchain, we should underscore the fact that this technology is still very new (Tsiulin et al. 2020). Owing to its immaturity, blockchain technology currently lacks applicable standards (Jović et al. 2019) and is susceptible to interoperability problems, which limits its wider adoption and application (Van Rijmenam et al. 2018). Furthermore, blockchain is presently energy intensive (Jović et al. 2019), resulting in high (but spread-out) operational costs. These challenges require careful consideration for broad acceptance of the technology in the shipping sector.

Discussion

The research findings from the review of existing studies reveal that the adoption of blockchain technology can enable more efficient and faster flow of data (Jović et al. 2019). The application of blockchain technology in the shipping industry may help reduce paperwork, while fast-tracking transactions (Yang et al. 2019) and reducing operating costs. It can lead to enhanced control of the supply chain and improved administrative efficiency (Jović et al. 2019). Moreover, the review of prior studies

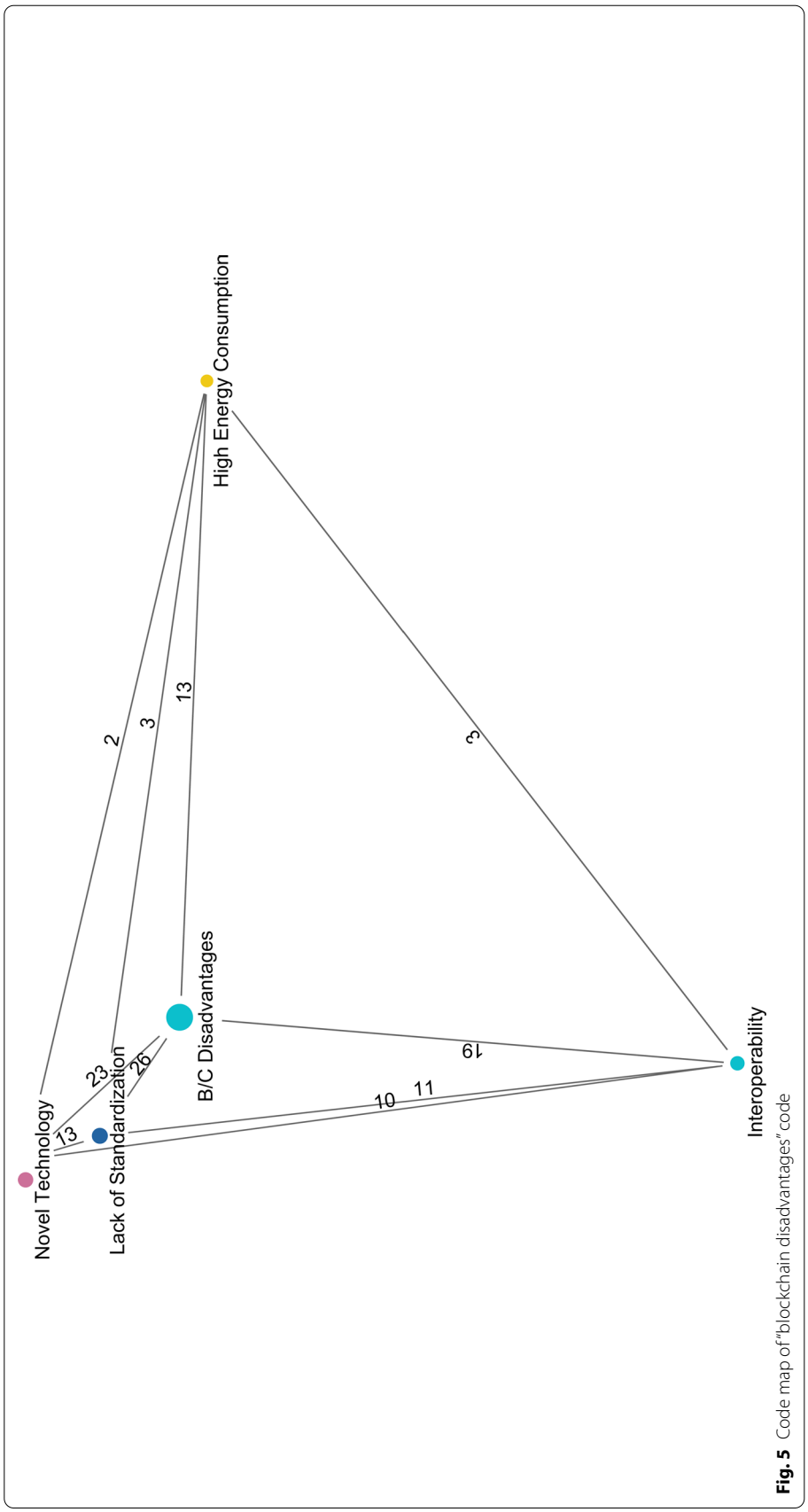

Fig. 5 Code map of "blockchain disadvantages" code

suggests, that blockchain may support the dissemination of real-time information on vessels and minimize shipping delays (Komathy 2018).

Another potential of blockchain that must be highlighted is the enablement of instant cargo tracking and accurate shipment prediction (Jugović et al. 2019). It facilitates the transparent sharing of information and digital transacting (Ølnes et al. 2017), and with its utilization of cryptography also offers the possibility of automated decision-making, which may change organizational design (Van Rijmenam et al. 2018). Furthermore, blockchain technology enables documents to be made available to all stakeholders in a fast and secure manner (Green et al. 2020). It thus promises to facilitate interoperability across market systems (Randall et al. 2017) and produce significant cost savings and improved efficiency in shipping operations (Loklindt et al. 2018). Moreover, blockchain technology can contribute to resolving the problems of the maritime industry related to information asymmetry, lack of trust, and undesirable delays (Filom and Van Hassel 2020).

Additionally, blockchain technology promises to support synergy among stakeholders in the shipping industry (Calvaresi et al. 2019; Lambrou et al. 2019). It offers opportunities for new ways of collaboration between internal and external actors in shipping operations (Jović et al. 2019), offering instant and trustworthy sharing of information that would significantly impact the industry (Diordiiev 2018). Indeed, blockchain technology may provide an innovative solution to operational inefficiencies in many industries.

However, following the summary of the extant literature, we may infer that there remain some issues and limitations to blockchain technology that are worthy of consideration to enable a more effective and efficient application of this novice technology in the future (Loklindt et al. 2018; Green et al. 2020). For example, its broad application requires a large amount of computing power (Jović et al. 2019; Singh et al. 2020), which could be concentrated in one country (Huhmo 2018). The power consumption implications should be addressed before the use of the technology becomes conventional (Van Rijmenam et al. 2018). As previously noted, blockchain technology is regarded as not yet fully developed because of the lack of appropriate standards and regulations (Jović et al. 2019) and is thus currently difficult to implement (Jović et al. 2019). The absence of a central authority and the immaturity of the system cause uncertainty among users (Jović et al. 2019). Moreover, some shipping players may not desire the transactional transparency of blockchain technology (Green et al. 2020).

There is, therefore, the need for further exploration of blockchain technology to evaluate its practical potential (Tsiulin et al. 2020). The development of regulations and the introduction of standards is one way in which the attractiveness of the technology can be strengthened (Yang et al. 2019). The application of artificial intelligence is another means of addressing user uncertainty (Calvaresi et al. 2019). Overall, the academic contribution of this research is connected to increasing the number of studies in the field of blockchain technology application in the shipping industry (Green et al. 2020). This research summarizes prior studies and provides a body of knowledge with a synthesis of the characteristics of this new digital technology and those of decision-making in the shipping industry with the intent to crystalize the potential contribution of blockchain to efficient decision-making.

Pertaining to managerial and practical implications, this research offers shipping managers some useful insights regarding blockchain technology. This new digital technology may present a source of competitive advantage for shipping firms and a way to strengthen their place in the competitive landscape (Cole et al. 2019). Managers should consider the potential contribution of blockchain to decision-making (i.e., reducing information asymmetry and enabling smoother transactions) and evaluate the option to invest in this new technology. In parallel, managers should also assess the necessary expertise of human resources to fully reap the benefits of this novice digital technology (Cole et al. 2019).

Conclusion

The findings of this study reveal several reasons for the adoption of blockchain technology for more effective decision-making in the shipping industry. These include inefficiencies in shipping operations, difficulties of data sharing, and information asymmetry. Although blockchain technology is still immature, it promises to be a panacea to these problems. The Fourth Industrial Revolution involves innovative modes of designing, producing, distributing, and paying for goods and services of which blockchain technology constitutes an essential and exciting element. The technology is expected to become significant to industry and society, offering the advantages of decentralization, cost reduction, and improved efficiency. It can be used in other transportation industries to simplify operations, enhance decision-making, and contribute to organizational efficiency and competitiveness.

This research explores a captivating subject that is associated with the application of an innovative digital technology in an exciting industry, such as the shipping industry. The actual contribution of this study is in identifying how the adoption of the blockchain technology in the shipping industry can influence decision-making and contribute to more effective sharing of information among stakeholders. The application of blockchain technology in the shipping industry will liberate decision-making and make it more democratic. However, further research is necessary to examine the use of the technology across industries to better appreciate its potential and identify any areas of concern.

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Author's information
K.G.-V. received an MBA in Financial Management in 2008 and a DBA degree from Edinburgh Business School Heriot-Watt University. She currently works as a part-time instructor in the American College of Greece and is a member of the ACG Center of Excellence in Logistics, Shipping and Transportation. Her current research interests include the application of knowledge management procedures in the shipping industry, managerial decision-making, and the impact of Industry 4.0 in the shipping sector.

Authors' contributions
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Availability of data and materials
The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Competing interests
The author declares that she has no competing interests.

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