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Digital information in maritime supply chains with blockchain and cloud platforms: Supply chain capabilities, barriers, and research opportunities

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ABSTRACT

Digital transformation plays a key role in improving information sharing and information processing in supply chains. Specifically, maritime supply chains require numerous data and document exchanges and can significantly benefit from digital information sharing (DIS). This notable potential has attracted attention and has resulted in a growing number of studies on blockchain platforms, cloud-based platforms, and other digital technology platforms. However, DIS adoption and execution is a complex process as it depends on various success factors and barriers and affects numerous capabilities and performance outcomes. Moreover, various information systems and management theories can be utilised to underpin these relationships. Our study aims to conduct a systematic literature review that uncovers dynamic capabilities, barriers, enablers and outcomes of DIS with blockchain and cloud-based platforms, illustrates the relationship between them, and discloses methods and theories applied in supply chains. We discuss different use cases of blockchain and cloud-based platforms for DIS in various business functions in supply chains. Particularly, we reveal six DIS-powered capabilities, five performance outcomes improved by the DIS, eight main barriers, and nine enablers of DIS implementation. The lack of theoretical underpinning and causal empirical studies is identified as an important gap in the literature. This study also presents precise future research directions that can help address these gaps.

1. Introduction

The never-ending quest for continuous improvement imposes a need for information, transaction, and cargo handling efficiency in supply chains (SC). A tidal wave of technological innovation and integration paves the way for digital transformation, which is an important vessel to accomplish continuous improvement goals in all SC functions (Nguyen et al., 2022). Digital platforms are an integral part of enabling digital transformation and they provide the infrastructure for information sharing. Considering that supply chains comprise several stakeholders and become more complex and dynamic in nature, Digital Information Sharing (DIS) platforms supported by blockchain and cloud technologies help for information sharing, exchange and processing in the operational, financial, customer relationships and sustainability functions of SCs (Jabbar and Dani, 2020; Choi and Siqin, 2022). The use of digital platforms also characterises Industry 4.0, through interconnectivity across members of a supply chain and across departments of an organisation in the supply chain (Tseng and Liao, 2015).

As the predominant mode of transportation in supply chains (with approximately 90 % of traded goods in volume), maritime transportation offers economical, reliable, sustainable, and efficient service between SC members and serves as one of the main engines of international trade and the global economy (Lambourdiere and Corbin, 2020; Iris and Lam, 2019a). In particular, a maritime supply chain refers to a collection of connected value chains in maritime services and transhipment functions and contains a significant number of independent actors such as shipping companies, ports and terminals, customs, shippers, hinterland operators, forwarders, waterways and navigation authorities, inland logistics, financial institutions, and government agencies.

A large number of monetary transactions and exchanges of data, documents and the paperwork arise from bookings, required confirmations, information processing, shipment tracking, collaboration, customs clearance, payment tracking, taxing, product authentication, customer services, emission reporting and regulation compliance in supply chains (Yang, 2019; Zeng et al., 2020). Digital information sharing is materialised through digital platform architectures such as application programming interfaces and electronic data interchange

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(EDI) in cloud-based platforms and blockchain-based platforms (Müller et al., 2020), and is still in the growth stage (Nguyen et al., 2022). Platforms such as AWS Supply Chain, CargoX, Flexport, GSBN, Maersk Spot, Maersk Flow, Oracle Transportation Management EDI, OneTouch EDI, SAP Shipment EDI, Wave BL, and T-Mining offer solutions for DIS and claim to contribute to operational, financial, sustainability, marketing, and security performance.

However, digital platforms cannot help sufficiently if the organisation does not create a set of routines, procedures, and collective activities (i.e. capabilities) which would mediate the effects of digital information sharing on company performance (Dutta et al., 2020; Yu et al., 2018). These capabilities can be built when the required success factors (i.e. enablers) are in place (Blome et al., 2013). Understanding the capabilities and enablers and how they relate to digital information sharing is paramount but might not be adequate. Barriers to adoption still arise from several factors.

Barriers, enablers, capabilities, and performance outcomes in the DIS context involve several complexities and trade-offs. DIS can power a variety of supply chain capabilities, which can eventually improve different supply chain performance outcomes. In addition, various information technology and management theories can be used to underpin these relationships (Zhu et al., 2022). The abundance of potential theories and relationships has created several avenues for research. Barriers, enablers and performance outcomes are of utmost criticality but have mostly been studied as isolated silos in the relevant SC literature. The literature lacks a study that uncovers and relates all barriers, enablers, and capabilities in a holistic view and points out potential theories and relationships in DIS implementation to guide researchers in future studies. We address these research gaps. In other reviews, the focus is mainly on information architectures and methodologies. For example, Liu et al. (2021) reviewed applications of blockchain technology in maritime SC and discussed the technology architecture of blockchain-based platforms. Similarly, Li and Zhou (2021) reviewed key blockchain structures and mechanisms used in maritime. Finally, Tijan et al. (2021) focused on digital transformation in the maritime sector and revealed the drivers and barriers to change.

The motivation of this study is to provide a systematic literature review (SLR) of digital information sharing with cloud-based and blockchain-based platforms in supply chains. The focus is on understanding the set of dynamic capabilities, enablers, and barriers, and their relationships and contributions to each performance metric. An assessment of the literature from a theory application of DIS in maritime domain is not available. Therefore, we also map the theories and methods used in the state-of-the-art to relate capabilities, enablers, and barriers. Finally, directions for future research are suggested. This content would contribute to the understanding and building of a strong basis for DIS adoption, design, management, acceptance, and performance analysis, especially in digital supply chain management research. We now list a set of objectives for achieving these goals. The first objective of this study is to identify enablers and barriers to DIS adoption and discuss their relationships (RO1). The second objective is to reveal which SC capabilities and performance outcomes can be improved via the implementation of DIS in maritime SC (RO2). The third objective is to uncover the theories and methods used in the state-of-the-art (RO3). Finally, we suggest future research directions that consider the relationships and the theoretical and methodological gaps identified in our study (RO4).

Our study mainly contributes to operations and supply chain management (OSCM) literature focusing on the maritime industry. The results of our paper are relevant to studies investigating the role and adoption of blockchain and cloud-based information sharing and processing in the operations of SCs. Information systems research can also benefit from our results. Our review is the first to approach DIS in maritime supply chains using operations and supply chain management lenses, including the capabilities, success factors, barriers, and theories used. This study contributes to the literature by adopting a holistic approach and uncovering the success factors for DIS adoption, capabilities and outcomes improved by DIS implementation. Our research also contributes by presenting future research directions in two important domains: DIS adoption in maritime SC and the role of DIS in dynamic capabilities and performance outcomes.

The remainder of the paper is organised as follows: Section 2 provides an overview of the systematic literature review methodology. Section 3 discusses the results of the review. Future research directions are discussed in Section 4, and conclusions are presented in Section 5.

2. Methodology

A systematic literature review approach is adopted. SLR requires a transparent, replicable, and coherent process; therefore, it is considered a comprehensive and rigorous framework for literature review (Thorpe et al., 2005; Tranfield et al., 2003). To ensure this process, the SLR necessitates a thorough protocol in which the steps are explicitly stated. In this study, we implement the three-phase approach described by Tranfield et al. (2003). Fig. 1 shows a schematic of the three-phase approach.

2.1. Phase I: planning the research process

Phase I includes three steps: defining the research aim and questions, developing the review protocol, and identifying the inclusion and exclusion criteria. Step 1 determines the research aim and questions, as explained in the Introduction. Step 2 includes the selection of the database, defining suitable keywords, and identifying search strategies. In this study, we use the Scopus database to select articles and collect journal articles using the "title, abstract, and keyword" search in the database.

For the first and second research objectives, different keyword selection criteria are specified. The collected articles are used to accomplish the third and fourth research objectives, respectively. The keyword search is completed following the three-level keyword structure (Table 1) proposed by Rajagopal et al. (2017). The keywords at each level are connected by the "OR" Boolean operator, while each level is connected by the "AND" Boolean operator.

Levels 1 and 2 keywords are used for both research questions. Since the research focuses on the impact of digital platforms on maritime SC, to retrieve articles that focus on this topic, we employ "information sharing", "information exchange", "digitali*", "blockchain", "platform", and "booking system" as keywords in Level 1. Level 2 explicitly uses the terms "maritime" and "shipping" to include all potential articles conducted in the maritime or shipping industry. For both research questions, a small set of Level 3 keywords is used to collect relevant articles due to the specific terminologies used in observing the changes in the performance and enabling capabilities and identifying digitalisation enablers and barriers, as suggested by Moussaoui et al. (2016). A total of 554 articles were identified for RO1, while 950 articles were identified for RO2 at the end of keyword screening.

Step 3 includes the identification and implementation of the inclusion and exclusion criteria. We focus on articles that conducted research on information sharing through digital platforms in the maritime SC as an inclusion criterion. Only peer-reviewed articles -published online, including articles in the press and pre-publication are included in the study. The articles published until 30 September 2021 are considered in this study. The subject area of the studies is selected as "Business, management, and accounting". As exclusion criteria, review articles, conference papers, books, and book chapters are removed from the study. In addition, articles written in languages other than English are excluded from the study. After implementing the inclusion and exclusion criteria, 276 and 583 studies were eliminated from RO1 and RO2, respectively.

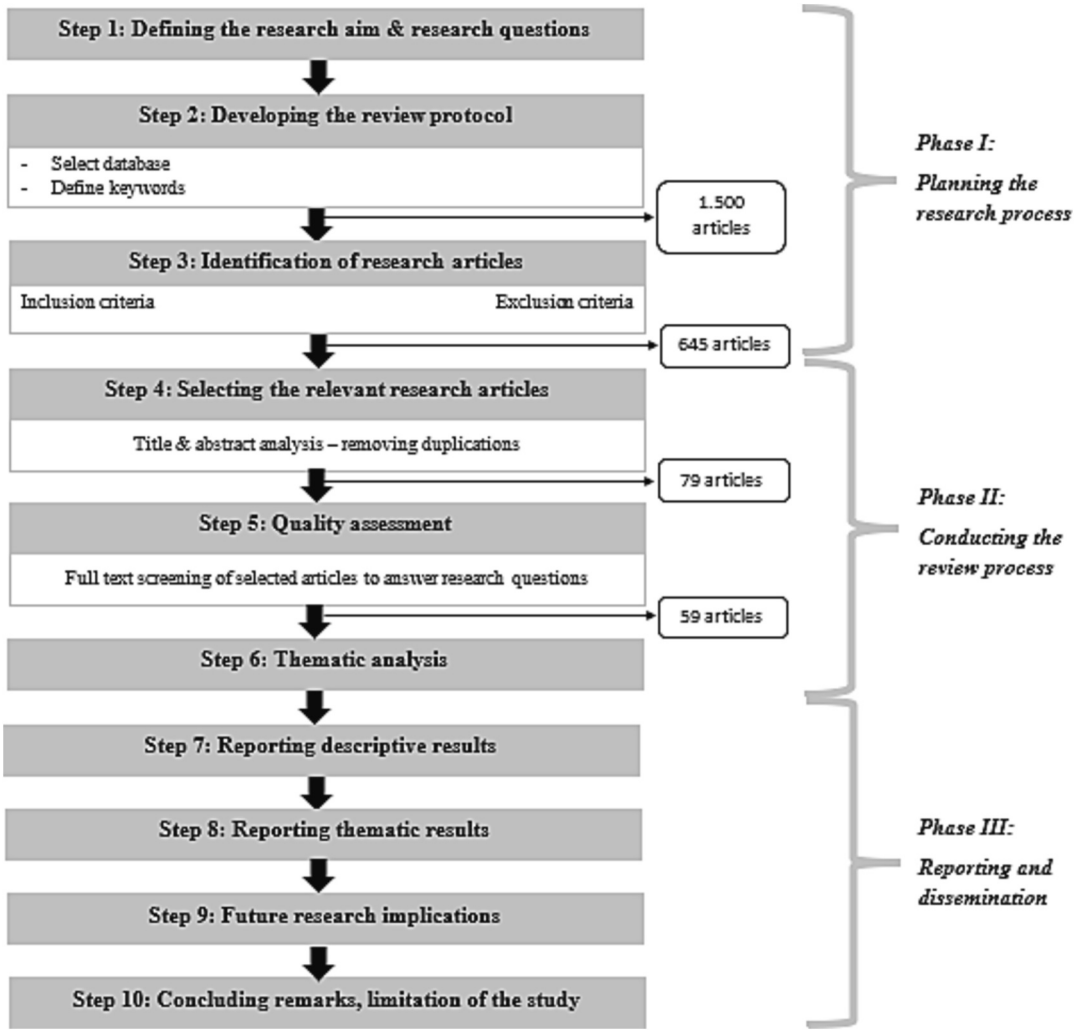

Fig. 1. SLR process.

Table 1
3-Level keyword structure.

Research objective	Levels	Keywords	Number of articles downloaded
RO 1	Level 1	maritime; shipping	554
	Level 2	information sharing; information exchange; digitali*; blockchain; platform; cloud; booking system	
	Level 3	challenge; enabler; success factor; driver; barrier; obstacle; facilitator	
RO 2	Level 1	maritime; shipping	950
	Level 2	information sharing; information exchange; digitali*; blockchain; platform; cloud; booking system	
	Level 3	capabilit*; performance	

2.2. Phase II: conducting the review process

Phase II consists of selecting relevant research articles (step 4), quality assessment (step 5), and analysis of the relevant data (step 6) in the SLR. Title and abstract analyses are conducted to select relevant research articles. At this stage, empirical-based research and conceptual articles are chosen to reveal conceptual developments in information sharing through digital platforms in the maritime SC. In addition, duplicates are removed at this stage. At the end of this stage, 43 and 36 articles were retained for RO1 and RO2, respectively. In Step 5, we examine all the articles and determine whether the selected articles answer the research questions. During this step, 20 articles were removed from the study. A total of 59 articles were used to conduct the SLR.

The last step of Phase II is to review and conduct the thematic analysis. During this phase, an initial table is developed, and the table includes purpose, utilised constructs, implemented methods and adopted theories. A coding scheme is developed, and the papers are classified to convert the vast dataset into a digestible and organised format. The coding scheme is designed to address each research question established inductively while reading the articles. The coding scheme includes dynamic capabilities, performance outcomes, barriers, enablers and their sub-categories, as well as methods and adopted theories.

The coding protocol was developed by an independent coder with a research background on DIS through blockchain and research team members. Another coder who did not know the research aim was also involved in the coding process (Surucu-Balci and Balci, 2023). To ensure inter-coder reliability, we applied Perreault and Leigh's (1989) technique, which states that the inter-coder reliability should be between 0.8 and 1.0 to obtain a reliable coding result. The inter-coder reliability is 0.95, which is satisfactory.

3. Review results

This section provides the results of descriptive and thematic analyses of 59 articles. Descriptive results, including the publications per year and main journals, are provided in the descriptive results (Section 3.1). The thematic analysis results, which were conducted to analyse the existing research content, were provided by considering the research questions. The conceptual framework is given in Section 3.2. The barriers and enablers (success factors) to adopting digital technologies in maritime SC are provided in Sections 3.2.1 and 3.2.2, respectively. The SC capabilities and their impact on performance is explained in Section 3.2.3. Methods and theories utilised while investigating the topic are explained in Section 3.3.

3.1. Descriptive results

Fig. 2 shows the publication trends in information sharing through digital platforms in the maritime SC. Although we did not restrict the publication years for the SLR, we found that the earliest articles on the subject were published in 2006. The findings also demonstrate that the number of publications on information sharing through digital platforms has significantly increased in the past few years.

Table 2 shows the top eight journals with more than one publication on information sharing and processing through digital platforms in the maritime SC.

A total of 30 downloaded articles focused on blockchain-based platforms, while 29 examined information sharing using other platforms, such as cloud-based application programming interfaces and EDI in the maritime supply chain.

3.2. Conceptual framework

We develop a conceptual framework to illustrate findings of RO1 and RO2 as shown in Fig. 3. The upper part of the framework demonstrates enablers and barriers to DIS adoption (RO1), while the bottom part of the framework shows capabilities and performance outcomes that can be achieved or improved through the usage of DIS (RO2). The framework indicates that DIS adoption depends on enablers and barriers whereas it suggests that DIS adoption can positively affect several dynamic capabilities and performance outcomes.

Fig. 3 also demonstrates that some capabilities can positively impact performance outcomes. Some enablers in the framework may look similar to capabilities and performance outcomes at first glance. It should be noted that two separate systematic reviews is conducted for the two objectives by using different keywords. Some conceptual overlap is expected between enablers and performance outcomes because enablers include perceived usefulness of DIS adoption, which are positive expectations of users if they are to adopt the technology.

Table 2
Top eight journals with the number of articles.

Name of the journal	Number of published articles
Transportation Research Part E: Logistics and Transportation Review	6
Technological Forecasting and Social Change	3
International Journal of Production Economics	3
International Journal of Production Research	3
Maritime Policy and Management	3
Research in Transportation Business and Management	3
Computers in Industry	2
Computers and Industrial Engineering	2
Others	34
Total	59

3.2.1. Barriers of digital information sharing in maritime supply chains

Eight barriers were identified in this study. The identified barriers were classified according to the Technology-Organisation-Environment (TOE) framework. TOE is an organisational level of technology acceptance theory that aims to demonstrate factors affecting the technology adoption of organisations (Awa et al., 2017). The TOE framework suggests that adopting an organisation to technology depends on technological, organisational, and environmental contexts (Tornatzky and Fleischer, 1990). Technological context refers to the characteristics of the technology. Organisational context refers to all organisations' characteristics and resources that affect adoption. Environmental context involves external factors that can affect technology adoption, such as the industry's structure, regulatory framework, and influential stakeholders (Baker, 2012). Technology-related barriers include cost, scalability, and infrastructure. Organisation-related barriers include conservatism, a lack of human resources, a lack of knowledge and trust, and privacy concerns. Environment-related barriers involve a lack of regulation and support from stakeholders. Table 3 shows the identified barriers, their classifications, and the authors who used these barriers in their study.

3.2.1.1. Adoption cost. Cost is one of the main barriers to adopting DIS platforms. The discussion of the incurred cost of adopting DIS platforms in the literature is mainly focused on the following points: initial development and maintenance costs (Ho and Hsu, 2020; Zhou et al., 2020; Gausdal et al., 2018), switching to a new system and learning

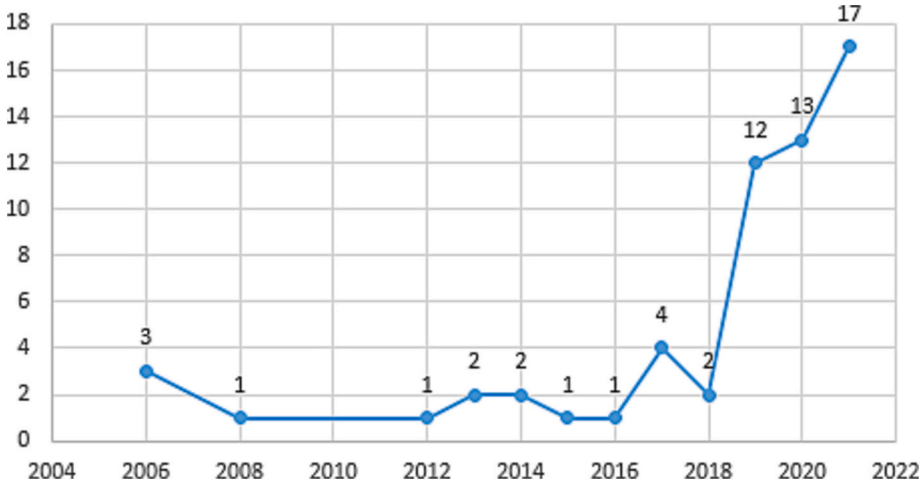

Fig. 2. Article distribution by year of publication.

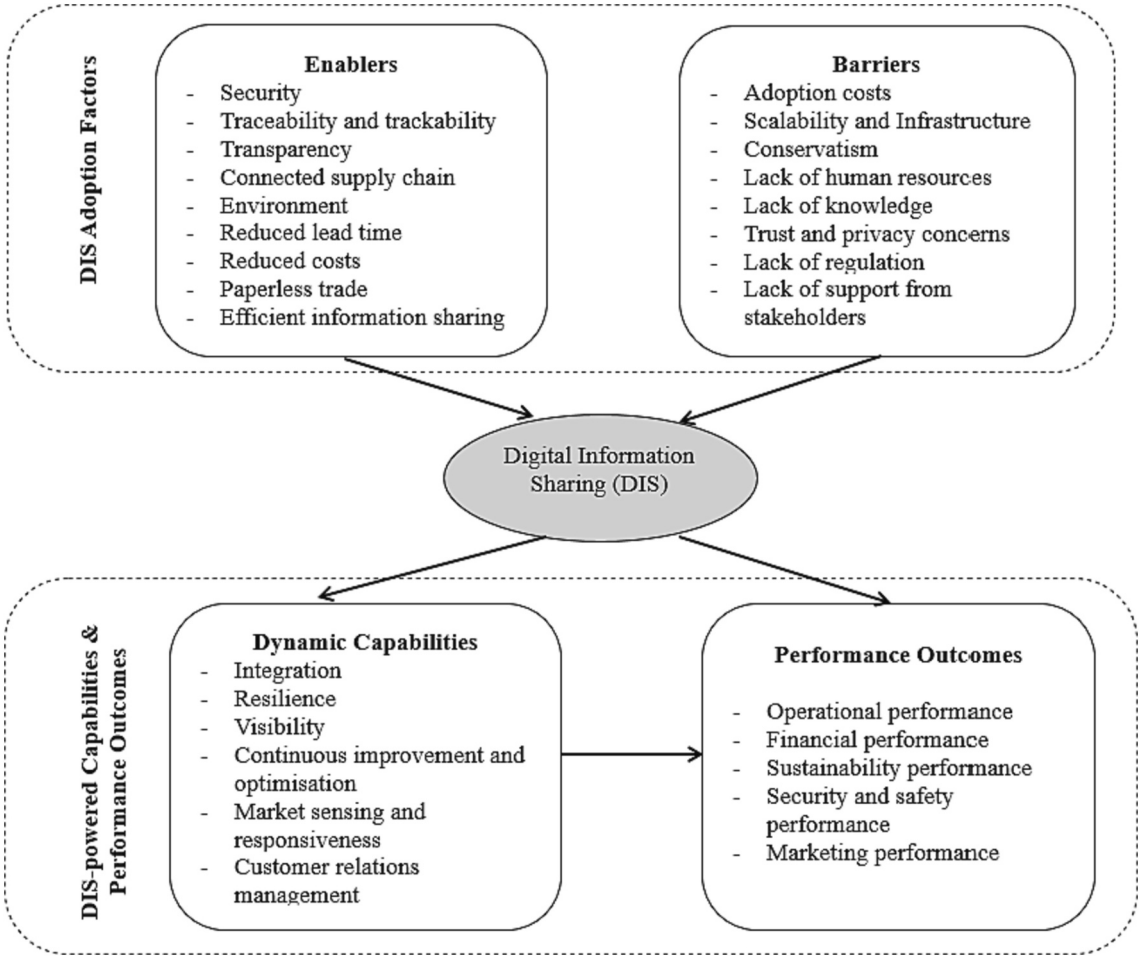

Fig. 3. Conceptual framework.

costs (Gausdal et al., 2018), establishing smart contracts (Ahmad et al., 2021), security expenses (Tan and Sundarakani, 2020), and energy costs (Zhou et al., 2020). Significant monetary investments must be dedicated to the adoption of DIS platforms. Papathanasiou et al. (2020) ascertained that some stakeholders may have recently invested in different technological systems (e. g. alternative enterprise resource planning (ERP) systems) incompatible with DIS platforms. In these cases, additional investments are required to make the systems compatible with DIS platforms. In addition, it is essential to train customers and employees to use new platforms in an authorised manner.

Smart contracts can be used to utilise DIS platforms efficiently. Smart contracts are applications that are automatically implemented when predetermined criteria are satisfied; platform members must invest in smart contracts (Ahmad et al., 2021). Improving security, which requires additional investments, becomes more vital as technology evolves and platform members become dependent on these technologies (Tan and Sundarakani, 2020). Real-time information sharing requires live power; especially in blockchain-based DIS platforms, when a new node is created, it needs to be connected to other nodes, which requires considerable energy (Zhou et al., 2020).

3.2.1.2. Scalability and infrastructure. Maritime supply chain stakeholders exchange documents to complete transportation (Zeng et al., 2020). During these exchanges, partners mostly use independent and heterogeneous information systems (Tijan et al., 2021), that are non-interoperable. This situation leads to inconsistencies and manual documentation (Ahmad et al., 2021). The DIS platforms can prevent this inefficiency. However, to perform effectively, DIS platforms must be adopted on a larger scale by members of the maritime supply chain. Members must update and invest in their system technologies to ensure compatibility. The size of technology investment and infrastructure requirements, such as Internet speed, is another obstacle to the adoption of DIS platforms (Gausdal et al., 2018). Platform members must have similar infrastructure and technological systems, or existing systems must be compatible. This necessity requires a significant investment in infrastructure. It may be more difficult for small-scale enterprises operating in international trade to make such investments.

3.2.1.3. Conservatism. Culture in the maritime industry is another barrier to DIS platform adoption. The maritime industry's low uptake of adopting new technology and the structural characteristics of organisations in the maritime supply chain incline the industry to be conservative (Zhou et al., 2020; Gausdal et al., 2018). The maritime industry is considered a late adopter of digital technologies and lacks digital innovations in the operational process (Papathanasiou et al., 2020). The structural business characteristics of the maritime supply chain members, such as being a family owned business, hierarchical structures of the company, and having senior management conservative decision-makers, impede the decision-making process and lead to delays in the adoption process (Gausdal et al., 2018).

3.2.1.4. Lack of human resources and knowledge. The literature review revealed that the lack of human resources with digital skills and limited knowledge of technology is another barrier to adopting DIS platforms (Zhou et al., 2020; Orji et al., 2020). It is essential to have human resources who know how to use DIS platforms. Therefore, DIS platform

Table 3
Identified barriers to adopting DIS in the maritime supply chain.

Classification	Barriers	References
Technology	Adoption costs	Ahmad et al., 2021; Alkhoori et al., 2021; Zeng et al., 2021; Tan and Sundarakani, 2020; Bavassano et al., 2020; Ho and Hsu, 2020; Papathanasiou et al., 2020; Perkušić et al., 2020; Schmidt and Wagner, 2019
	Scalability and infrastructure	Nguyen et al., 2021; Orji et al., 2020; Perkušić et al., 2020; Ahmad et al., 2021; Bavassano et al., 2020; Gausdal et al., 2018; Yang, 2019; Zeng et al., 2021; Zhou et al., 2020
Organisation	Conservatism	Tan and Sundarakani, 2020; Shardeo et al., 2020; Papathanasiou et al., 2020; Zeng et al., 2020; Schmidt and Wagner, 2019; Gausdal et al., 2018; Chen et al., 2019; Poulis et al., 2013
	Lack of human resource	Bavassano et al., 2020; Papathanasiou et al., 2020; Zhou et al., 2020; Nguyen et al., 2019
	Lack of knowledge	Papathanasiou et al., 2020; Perkušić et al., 2020; Zhou et al., 2020; Nguyen et al., 2019; Orji et al., 2020
	Trust and privacy concerns	Irannezhad and Faroqi, 2021; Pu and Lam, 2021a; Tan and Sundarakani, 2020; Ho and Hsu, 2020; Papathanasiou et al., 2020; Zeng et al., 2020; Zhou et al., 2020
Environment	Lack of regulation	Orji et al., 2020; Papathanasiou et al., 2020; Perkušić et al., 2020; Ahmad et al., 2021; Bavassano et al., 2020; Ho and Hsu, 2020; Yang, 2019; Zeng et al., 2020; Zhou et al., 2020
	Lack of support from stakeholders	Tan and Sundarakani, 2020; Zeng et al., 2021; Zeng et al., 2020; Papathanasiou et al., 2020; Perkušić et al., 2020; Zhou et al., 2020; Nguyen et al., 2019; Orji et al., 2020

adoption requires upskilling and reskilling current employees or hiring new people. However, the number of people capable of using this system is limited (Papathanasiou et al., 2020). Tijan et al. (2021) stated that a lack of digital skills and trained human resources might hinder DIS adoption in the maritime supply chain. This problem might accelerate in the future, considering that the emergence of new technologies necessitates additional skill sets and technological knowledge. In addition, the lack of knowledge is not only about not knowing the digital skills but also a lack of understanding of how DIS platforms operate (Zhou et al., 2020). An insufficient understanding of the working principles of platforms causes perceived insecurity towards DIS platforms (Carlan et al., 2020). Because DIS platforms are evolving, when they are mentioned, they can be confused with cryptocurrencies. The fluctuations experienced in cryptocurrencies and inadequate insights into how the system works cause similar insecurity as reflected on DIS platforms.

3.2.1.5. Lack of regulations. Although DIS platforms offer various advantages, they are still an emerging technology that lacks standards and regulations (Ahmad et al., 2021; Bavassano et al., 2020; Pagano et al., 2022). In most cases, information is scattered worldwide to ensure immutability; however, this situation leads to uncertainty in deciding which jurisdictions' laws and rules can be implemented in certain transactions (Zeng et al., 2021). Local governments' approach to using DIS platforms for international trade is unclear. In international trade, government offices and officials are involved in activities such as checking shipments and filling out documents with "wet-sign". While developed countries support the use of DIS platforms, the level at which they will be adopted in some developing and underdeveloped countries (Tan and Sundarakani, 2020) is still unclear. In addition, no central entity is liable and responsible for providing DIS platform services if they are blockchain-based (Anjum et al., 2017). The current DIS platforms may not match privacy laws, for example, the General Data Protection Regulation (GDPR) (Berberich and Steiner, 2016).

3.2.1.6. Lack of trust and privacy concerns. Although studies imply that DIS platforms are safe to use (Irannezhad, 2020; Pu and Lam, 2021a), a lack of trust and cybersecurity concerns have appeared as barriers to adopting DIS platforms in maritime supply chains, where one of the profit sources is mainly based on information asymmetry and uncertainty (Papathanasiou et al., 2020). The literature review identified that a lack of trust and privacy concerns are concentrated on the confidentiality of data exchange (Tan and Sundarakani, 2020; Zeng et al., 2020), cyber-attacks (Balci and Surucu-Balci, 2021; Zhou et al., 2020), and the risk of losing control (Papathanasiou et al., 2020). Scepticism regarding data security focuses mainly on the risk of disclosing confidential business information and documents shared via DIS platforms to third parties. (Zhou et al., 2020). Cyber-attacks on companies that are pioneers (such as Maersk and MSC) in adopting new technologies cause increased distrust of new technologies (Balci and Surucu-Balci, 2021). Increased transparency leads to concerns among maritime supply chain members about causing loss of control of operational information (Papathanasiou et al., 2020).

3.2.1.7. Lack of support from stakeholders. The use and efficiency of DIS platforms will be limited if they are not adopted by the majority of stakeholders. Therefore, stakeholder support is a significant determinant in the adoption of new technologies (Orji et al., 2020). However, the literature review disclosed that a lack of support from stakeholders appears to be a barrier when adopting DIS platforms. There is a lack of stakeholder support in two ways. First, maritime SC actors do not support or lead each other in adopting new technology (Zeng et al., 2021; Papathanasiou et al., 2020). Papathanasiou et al. (2020) revealed that several actors do not use ERP systems; they complete transactions manually. Second, stakeholders within the organisation (such as top management and employees) do not support each other in adopting new technologies (Zeng et al., 2021; Tijan et al., 2021; Zeng et al., 2020). Top management, which constitutes senior-aged members or people who are sceptical about new technologies, is a crucial barrier when adopting DIS platforms (Zeng et al., 2020).

3.2.2. Enablers of digital information sharing in maritime supply chains

Nine enablers were identified based on the literature review. Similar to barriers, enablers are classified based on the adjusted TOE and Technology Acceptance Model (TAM) framework. Technology-related and environment-related enablers were taken from TOE, while perceived usefulness-related enablers were taken from TAM. While TOE is ideal for assessing technological and environmental enablers to adopt a DIS, it fails to explain perceived benefits from the usage of such platforms. TAM is ideal for that purpose because, according to the framework, perceived usefulness signifies the usefulness and benefits of the adopted technology (Davis, 1989). Perceived ease of use of TAM has not been utilised because our review did not result in any relevant enabler. That is, our review suggests easiness to use a DIS platform is not found as an enabler. Technology-related enablers are security and traceability, while transparency, connected supply chains, and the environment are identified as environment-related enablers. Perceived usefulness-related enablers include reduced lead time, reduced costs, paperless trade, and efficient information sharing. Table 4 lists the identified enablers and their classifications.

3.2.2.1. Security. Offering secure transactions and keeping a record of every activity has emerged as an important enabler of DIS adoption in the maritime supply chain. The security of DIS platforms is ensured by the decentralisation of information by entrusting authority between platform members, reaching consensus protocols, and cryptographic hashing functions (Hewa et al., 2021; Bavassano et al., 2020; Irannezhad, 2020). DIS platforms block transaction processes using encryption

Table 4
Identified enablers to adopting DIS in the maritime supply chain.

Classification	Enablers	References
Technology	Security	Ahmad et al., 2021; Alkhoori et al., 2021; Balci, 2021; Bavassano et al., 2020; Irannezhad, 2020; Chang et al., 2019; Philipp et al., 2019; Yang, 2019
	Traceability and trackability	Ahmad et al., 2021; Alkhoori et al., 2021; Pu and Lam, 2021a; Irannezhad, 2020; Lambourdiere and Corbin, 2020; Papathanasiou et al., 2020; Shardeo et al., 2020; Philipp et al., 2019; Mondragon et al., 2017
	Transparency	Ahmad et al., 2021; Pu and Lam, 2021a; Sarker et al., 2021; Tan and Sundarakani, 2020; Irannezhad, 2020; Lambourdiere and Corbin, 2020; Shardeo et al., 2020; Chang et al., 2019; Philipp et al., 2019
Environment	Connected supply chain	Peng and Wang, 2021; Pu and Lam, 2021a; Jiang et al., 2021; Heilig et al., 2017; Mondragon et al., 2017; Mogre et al., 2014; Poulis et al., 2013; Lambrou et al., 2008; Chung and Lau, 2006; Rai et al., 2006
	Environment	Ahmad et al., 2021; Liu et al., 2021; Pu and Lam, 2021b; Zhao et al., 2020
Perceived usefulness	Reduced lead time	Ahmad et al., 2021; Peng and Wang, 2021; Jacobsson et al., 2020; Jiang et al., 2021; Papathanasiou et al., 2020; Lam and Zhang, 2014; Poulis et al., 2013; Rai et al., 2006
	Reduced costs	Ahmad et al., 2021; Irannezhad and Faroqi, 2021; Peng and Wang, 2021; Pu and Lam, 2021a, 2021b; Tijan et al., 2021; Bavassano et al., 2020; Dutta et al., 2020; Ho and Hsu, 2020
	Paperless trade	Ahmad et al., 2021; Irannezhad and Faroqi, 2021; Pu and Lam, 2021a, 2021b; Dutta et al., 2020; Papathanasiou et al., 2020; Shardeo et al., 2020;
	Efficient information sharing	Pu and Lam, 2021a, 2021b; Ho and Hsu, 2020; Irannezhad, 2020; Jacobsson et al., 2020; Jiang et al., 2021; Papathanasiou et al., 2020; Shardeo et al., 2020; Schmidt and Wagner, 2019;

techniques so that members can complete transactions securely (Zhou et al., 2020). DIS platforms maintain tamperproof and permanent registries of past transactions (Schmidt and Wagner, 2019). Moreover, smart contracts maintain all the changes that occur on platforms (Chang et al., 2019).

3.2.2.2. Traceability and trackability. Traceability, the awareness of the processes that the product endured from its origin to its final destination (Cousins et al., 2019), is one of the most substantial enablers. Similarly trackability, the current snapshot of the supply chain including the ability to track individual cargo, payment, etc., is also an important enabler of the DIS platforms. Traceability and trackability phase out data discrepancies. For instance, equipped with Internet of Things (IoT) and sensors, smart contracts can reveal not only a container's location, but also its content and share real-time data on the platform (Irannezhad and Faroqi, 2021). The immutability feature of DIS platforms can provide real-time tracking of the activities of commodities from origin to end customers in existing tracking systems (Pu and Lam, 2021a). Improving tracking and tracing enhances supply chain visibility, culminating in better credibility (Wang et al., 2019).

3.2.2.3. Transparency. Transparency in the maritime supply chain, which can be achieved by adopting DIS platforms, facilitates efficient operational planning, diminishing cargo damage risk, or cargo disappearance (Jugović et al., 2019). DIS platforms enable transparency in terms of data transparency (Pu and Lam, 2021a; Shardeo et al., 2020) and operational transparency, such as the transparency of transport routes (Tijan et al., 2021) and business transactions (Hewa et al., 2021; Bavassano et al., 2020; Dutta et al., 2020; Pu and Lam, 2021b). Extensive data have been created owing to the complex and dynamic nature of maritime supply chain operations. Distributed ledger technology which establishes the basis of DIS platforms, helps to disseminate data simultaneously, ensuring data transparency between members. DIS platforms enable full transparency to members by providing access to information about transactions and ownership transfers (Pu and Lam, 2021a).

3.2.2.4. Connected supply chain. DIS platform adoption enables connectivity of the maritime supply chain (Philipp et al., 2019; Heilig et al., 2017). DIS platforms connect members, provide end-to-end data access, authorise information sharing within maritime supply chains, and assist members in establishing strategic collaborations (Lambourdiere and Corbin, 2020). DIS platforms improve coordination and integration among members, ensuring supply chain visibility (Cagliano et al., 2021). Collaboration through DIS platforms acts as a catalyst to reduce logistics costs while enabling faster information flow, faster cargo delivery, and reduced time required to complete business processes (Tijan et al., 2012; Büyüközkan and Göçer, 2018). Further, collaboration facilitates trust among members via openness, transparency, and rapid information sharing (Liu et al., 2021).

3.2.2.5. Environment. Decarbonisation is one of the priorities of the maritime supply chain. The International Maritime Organisation (IMO) announced an initial strategy to reduce greenhouse gas emissions from international shipping (IMO, 2018). Digitalisation can play a significant role in achieving decarbonisation in maritime supply chains. More specifically, DIS platforms assist maritime supply chains in being decarbonised by eliminating manual document creation and sharing (Ahmad et al., 2021) and tracking ship emissions (Zhao et al., 2020). Transforming paper contracts into smart contracts eliminates unnecessary use of resources (labour, paper, printing) (Liu et al., 2021) and GHG emissions resulting from printing and transporting activities. With the help of the IoT and sensors, tracking ship emissions can become much more straightforward (Zhao et al., 2020). In case of possible environmental violation of the vessels (i.e. using heavy diesel oil in ECA), this can be recorded and updated via the platform, which can help the maritime industry to be more environmentally friendly. Finally, a blockchain based sustainability reporting and disclosure system can be adopted to report about the supply chain carbon data and ensuring its reliability.

3.2.2.6. Reduced lead time. DIS platform can significantly reduce lead times - i.e., 10 days reduction from a shipment that takes a total 34 days (Ganne, 2018). Reducing lead time can be achieved by switching to digitised documents (Pu and Lam, 2021a; Liu et al., 2021) and removing intermediaries (Hewa et al., 2021). Park (2018) revealed that the time required to process the paper documents, which includes completing, exchanging, and investigating the documents, constitutes 29 % of the total delivery time, which encompasses the time exported from production to retailers. Eliminating costly intermediaries reduces system delays (Cagliano et al., 2021).

3.2.2.7. Reduced cost. Longman (2017) estimated that between 15 and 20 % of the total shipping fee comes from the cost of paperwork. Cost reductions can be achieved by reducing transaction costs (Irannezhad, 2020; Orji et al., 2020) and paperless transactions (Zhou et al., 2020; Yang, 2019) by adopting DIS platforms. Transaction costs include searching for agents and information, contract establishment, controlling, monitoring, resolving disputes, and prosecuting contract execution (Irannezhad, 2020). DIS platforms diminish information collection and processing costs, outline and negotiate contracts, control and impose contracts, and maintain relationships (Schmidt and Wagner, 2019). Using smart contracts can substitute trade and transport documents,

enable payments, and lead to cost savings (Papathanasiou et al., 2020). The storage, processing, and management of paper-based documents requires various resources, sometimes causing delays in shipping dates and additional costs in ports. Adopting DIS platforms can help reduce the workload and costs associated with these paper-based documents (Zhou et al., 2020). Seatrade. (2018) predicted that costs could be reduced by up to $300 per container if information could be shared effectively.

3.2.2.8. Paperless trade. International trade depends on completing and sending various paper-based documents between stakeholders to transport commodities across different geographical locations (Choi and Siqin, 2022). Van Baalen et al. (2009) revealed that up to 40 organisations were involved in the process, and hundreds of documents were exchanged to complete the shipment of a single container. In the traditional system, sharing these documents may encounter difficulties, such as delays in filling out the document the next day owing to the end of working hours, the risk of document manipulation, inconsistency in data, difficulty in tracking data inconsistencies, high error rates in document completion, inefficiency, and destruction (Irannezhad and Faroqi, 2021; Yang, 2019; White, 2018).

DIS platforms can thoroughly solve these problems and preserve documents, for example, owing to smart contracts and immutability (Yang, 2019). Smart contracts and self-executing codes that are activated when the preordained conditions are met can replace paper-based processes and save time and cost by excluding intermediaries from the system (Ahmad et al., 2021). Smart contracts can be used to digitalise many paper documents, such as negotiable documents such as the bill of lading, commercial invoices, and certificates of origin (Pu and Lam, 2021a).

3.2.2.9. Efficient information sharing. The maritime supply chain is considered an information-sensitive industry (Gausdal et al., 2018) in which documents and information need to be completed as cross-border transactions. Cross-border transactions can take several days and depend mainly on the Society for Worldwide Interbank Financial Telecommunication system (Qiu et al., 2019). DIS platforms offer more efficient solutions than the current methods in terms of speed and cost (Hewa et al., 2021). Being a member of the DIS platform allows members to reach the desired information in a much shorter time via the platform instead of spending time finding the information sought from the relevant home page of each member (Dobrovnik et al., 2018). According to Ganne (2018), completion of the documentation process, which can take between seven and ten days, can be completed within four hours. In addition, eliminating intermediaries using DIS platforms will make the process cheaper while speeding up (Pu and Lam, 2021a). Seatrade. (2018) predicted that costs could be reduced to $300 per container if information could be shared effectively.

3.2.3. The impact of digital information on supply chain dynamic capabilities and performance outcomes

Dynamic capabilities are a group of routines, procedures, learned approaches, and collective activities that help a company manage and adjust key practices and develop its resource base to retain and regain a sustainable competitive advantage and business excellence. Emerging from resource-based view (RBV), dynamic capabilities are commonly used to explain the higher relative company performance over time in different markets, but notably, capabilities are more valuable when they are case-specific and non-substitutable (Eisenhardt and Martin, 2000). Specifically, supply chain dynamic capabilities have similar properties and apply for abundant SC practices, including intra-organisational activities (e.g. product/service design, business operations, marketing) and inter-organisational activities (e.g. freight transportation, financial transactions, procurement/sales, logistics, collaborative project management).

To have a well-functioning SC, organisations must ensure an effective and efficient flow of information and transactions, and digital platforms facilitate and enhance these practices between SC members. However, earlier studies have shown that digital platforms do not sufficiently contribute to performance if the organisation does not underpin higher-order capabilities through platform use (Irfan et al., 2019). Therefore, in this review, we first discuss how different supply chain capabilities mediate the effects of digital information sharing on organisational performance in maritime supply chains. In particular, maritime supply chains have abundant opportunities to enhance capabilities which mediate the relationship between digital information sharing and supply chain performance.

The literature review provides six primary supply chain dynamic capabilities grounded in the theory: integration, resilience, visibility, optimisation and continuous improvement, market sensing and responsiveness, learning, and customer relations management. In Table 5, we report studies that address the relationship between each dynamic capability and digital information sharing.

We now discuss the relationship between supply chain capabilities and DIS in maritime SC.

3.2.3.1. Integration. Integration includes both external and internal aspects. External integration, or inter-organisational integration, as a higher-order capability, can be nurtured using three capabilities: collaboration, coordination, and cooperation between SC partners.

Coordination and cooperation are intertwined terms in which common goals are set with coordination, and these goals are implemented with cooperation. Therefore, cooperation follows coordination. Cooperation entails an organisation's ability to coordinate physical, information, and transaction flows, and conduct joint activities with SC partners to enable smooth operations. In maritime SC, DIS facilitates coordination for logistics-related decisions such as expected cargo arrival time management (Jacobsson et al., 2020; Lambrou et al., 2008; Venturini et al., 2017), inventory tracking and management (Li et al., 2016; Pu and Lam, 2021a), capacity sharing (e. g. slot sharing) and management (Tseng and Liao, 2015; Peng and Wang, 2021), customs management at ports (Ahmad et al., 2021), cargo synchronisation between services (Jacobsson et al., 2020), uncertainty and disruption management, and ordering and booking management (Chung and Lau, 2006; Tan and Sundarakani, 2020), and transaction-related decisions such as payment planning, payment settlement verification (Ahmad et al., 2021), and contractual obligations management (Jiang et al., 2021).

The DIS for cargo information (e. g. electronic bills of lading), ship information, truck arrival time information, performance metric

Table 5
Supply chain dynamic capabilities and digital information sharing in maritime SC.

Capabilities	References
Integration	Chung and Lau, 2006; Heilig et al., 2017; Jacobsson et al., 2020; Jiang et al., 2021; Lam and Zhang, 2014; Lambourdiere and Corbin, 2020; Lambrou et al., 2008; Li et al., 2016; Peng and Wang, 2021; Tseng and Liao, 2015
Resilience	Lai et al., 2019; Lam and Zhang, 2014; Li et al., 2016; Nguyen et al., 2019; Nguyen et al., 2021; Urciuoli and Hintsa, 2021
Visibility	Alkhoori et al., 2021; Fahim et al., 2021; Jiang et al., 2021; Lambourdiere and Corbin, 2020; Mondragon et al., 2017; Tan and Sundarakani, 2020
Continuous improvement and optimisation	Cristea et al., 2017; Heilig et al., 2017; Li et al., 2016; Mondragon et al., 2017; Zerbino et al., 2019; Zhang et al., 2006; Zhong et al., 2021
Market sensing and responsiveness	Chung and Lau, 2006; Lam and Zhang, 2014; Schmidt and Wagner, 2019; Tseng and Liao, 2015
Customer relations management	Balci, 2021; Chung and Lau, 2006; Hirata, 2019; Lambrou et al., 2008; Tsamboulas et al., 2012

information, ship and cargo tracking information, and cross-border payment information is paramount for the coordination of logistics, pricing, and transaction activities. Suitable and reliable mechanisms are required to achieve this goal. Blockchain, which offers transparent and standardised information sharing across SC, can mediate the coordination of shipment management through smart contracts (Lambourdiere and Corbin, 2020), custom management and taxing, standardise asset, product authentication and product certification, and documenting (Ahmad et al., 2021; Pagano et al., 2022). A smart contract automatically runs processes (e.g. demurrage payment, shipment release, violation tracking, emission reporting) when necessary conditions are met based on the information on the blockchain (Pu and Lam, 2021a). This facilitates coordination without human involvement, enhances security, and accelerates communication between SC partners (Hvolby et al., 2021).

Inter-organisational collaboration requires a more strategic decision for collective ownership of decisions, resulting in shared creation and help for all organisations. Digital information sharing nurtures collaboration in purchasing, communication, planning, forecasting, and joint process design and development in response to market fluctuations. Collaboration can materialise strategic and tactical decisions, such as investment in new capacity building, horizontal or vertical integration, joint ventures, profit sharing (Wen et al., 2019), pricing (Lam and Zhang, 2014), joint service contract management (Chung and Lau, 2006), energy information systems management (Iris and Lam, 2019b) and business service redesign (Heilig et al., 2017).

The extent of strategic and tactical information sharing depends on several factors, such as dependence on the information supplier, IS infrastructure quality, and trusting beliefs. In this scope, the relationship between capabilities, operations, and performance is studied in the state-of-the-art. For example, DIS between shipping companies and port operators would facilitate the way of conducting operations and ensure large quantities and continuous cargo flow from shippers, which would allow further strategic collaboration. Additionally, the dynamic requirements of customs and port authorities can be managed in a standardised way when cloud-based information sharing and processing are in place (Heilig et al., 2017). However, the relationship between capabilities and supply chain strategies is not well understood. The nature and complexity of supply chain topology might impose additional strategic integration requirements (e.g. supplier-buyer integration, marketing orientation, sourcing flexibility) for dynamic supply chain capabilities.

Internal integration, so-called cross-functional integration, refers to processing new information into the organisation's knowledge base and integrating in-house supply chain activities. This capability is supported by well-functioning DIS according to information processing theory (Swink and Schoenherr, 2015). Processes and behavioural elements which help understand internal stakeholder needs serve as an important capability for organisations (Handfield et al., 2015). Especially, cross-functional integration ensuring pricing, operations, marketing, and purchasing departments' alignment would process the information received more efficiently and reveal the benefits of the information in maritime SC (Lambourdiere and Corbin, 2020).

3.2.3.2. Resilience. Resilience is a collective and adaptive capability that comprises readiness, robustness, recoverability, and risk awareness against unexpected, unprecedented or unknown events, disruptions, or scenario realisations. In this review, we discuss the impact of digital information sharing on these components. A key element of resilience is to model, sense, and predict future risks and possible disruptions in advance. DIS delivers comprehensive inputs for each SC member and helps improve forecasting and planning quality for better risk management, vulnerability mapping, and readiness. First, sharing market forecasts (Lai et al., 2019; Li et al., 2016), regulation and technology scenarios, and unpredictable truck and ship arrival times (Jacobsson et al., 2020; Iris and Lam, 2019a) facilitates risk pooling and robustness building in shipping and port services in the short to medium terms. Second, DIS is expected to offer the ability to get informed about the excess and available resources; then, the organisation can access and use these resources to respond to unexpected events for contingency planning which might entail SC reconfiguration, cargo re-routing, capacity deployment, etc. Third, responsiveness after disruptions, including claims and conflict management (Lam and Zhang, 2014), promptness of the response to enquiries (Nikghadam et al., 2021), financial transactions (Dutta et al., 2020) and communication in customer relations, is improved by the DIS, especially in recent demand and supply shocks such as the COVID-19 pandemic, the blockage of the Suez Canal, financial crises, and long-lasting port congestion. The use of blockchain-based DIS might bring an additional layer of resilience as sequel risks, such as loss of cargo, cargo depreciation, detainments, accidents, dangerous goods detection, and problem detection, are considered in the smart contract design phase (Nguyen et al., 2019, 2021; Ahmad et al., 2021; Urciuoli and Hintsa, 2021) and lessen the risks in financial and transactional relationships (Schmidt and Wagner, 2019).

3.2.3.3. Visibility. Visibility refers to the awareness of traceability, trackability and the transparency in the supply chains. Institutional isomorphism and institutional theory suggest that several maritime supply chain members of the same type (e.g. ports) can implement similar ICT technologies and imitate each other to gain visibility (Mondragon et al., 2017). Fahim et al. (2021) and Mondragon et al. (2017) presented detailed Physical Internet (PI) architectures (network of networks) based on DIS for track-and-trace at seaports. The ICT platform ensures visibility from the long term to real time with interoperability among all SC components (Jiang et al., 2021). Alkhoori et al. (2021) used smart containers, blockchain, and IoT to track and monitor the storage conditions of vaccines which can easily depreciate. Transparent information sharing through blockchain has been noted as a mediator of visibility which enhances performance (Dutta et al., 2020; Lambourdiere and Corbin, 2020; Tan and Sundarakani, 2020).

3.2.3.4. Continuous improvement and optimisation. Continuous improvement and optimisation is the ability to regularly revisit all supply chain processes and systems, and to improve and optimise them at a continuous and lasting pace. Hyland et al. (2003) outlined factors that support continuous improvement (CI) and optimisation, and noted that the CI can be based on mathematical and algorithmic approaches, and can be applied in operations, pricing, processes, etc. In maritime supply chains, ship performance information can be shared automatically with ship brokers during cruising in the open sea, and real-time weather routing and speed optimisation can be conducted to save fuel (Cristea et al., 2017; Bai et al., 2022). A real-time information exchange platform which runs optimisation algorithms for determining container transportation decisions using tracking data and traffic prediction continuously improves the drayage operations of hinterland operators (Heilig et al., 2017) and energy management systems in maritime (Iris and Lam, 2021). CI can also be implemented in the procedural documentation. Data analytics methods (e.g. process mining and machine learning) can be embedded into data exchange platforms to assess datasets from freight transportation processes (Zerbino et al., 2019). In this way, issues in the procedures can easily be detected in real time, and the procedures can be updated to improve business performance. DIS can underpin CI's capability in pricing and inventory management. The impact of the bullwhip effect, which is the demand distortion (and consequently, inventory accumulation) that transfers upstream in the SC, can be reduced using optimisation and real-time cargo information sharing between SC partners (Li et al., 2016; Zhang et al., 2006). Finally, shipping freight rates can be optimised when SC partners share information (Zhong et al., 2021).

3.2.3.5. Market sensing and responsiveness. Market sensing and responsiveness refers to building the promptness in the supply chain to adapt to changes in the market and business environment in the short term (i.e. agility) and the ability to address the altering needs of customers in the long term (i.e. adaptivity) in the SC (Aslam et al., 2018). Digitalisation and using digital platforms have been presented as enablers of agility and adaptability (Fawcett et al., 2011). Specifically, DIS has proven to be helpful when it is used to obtain information about customer and vendor requirements, specifications, orders, and communications (Chung and Lau, 2006; Lam and Zhang, 2014). Ultimately, using DIS with all partners enhances the information gathered about the market, and the company can use this information to make informed decisions to reconfigure the SC. In addition to SC partners, structured information flows from competitors, regulators (such as International Maritime Organisation, IMO), and stakeholders are also required to adapt to necessary changes in a long-term relationship. Therefore, considering the traditional and conservative nature of this industry, market sensing and responsiveness are cardinal capabilities in maritime. In the longer planning horizon, behavioural acts and company culture can also be shaped through information sharing practices (Tseng and Liao, 2015).

3.2.3.6. Customer relations management. Customer relations management specifically focuses on customer orientation, customer loyalty, customer segmentation, interaction management, and planning. In short-to-medium term operational planning, DIS facilitates customer relationship practices, including the collaborative, planning, forecasting, and replenishment (CPFR) module (Panahifar et al., 2015). The good features of digital platforms, such as ease of use, usefulness, and automatic responses, positively impact digital satisfaction which, in turn, supports customer loyalty (Balci, 2021; Hirata, 2019; Tsamboulas et al., 2012).

Understanding how performance is improved by using digital information sharing is a critical task for organisations. Thus, we now discuss the organisational performance metrics used in the state-of-the-art for analysing the positive impact of DIS in maritime SC. In this review, we focus on higher-level performance metrics, and present studies that address this relationship in Table 6. The literature review provides five higher-level (categories of) performance metrics: operational, financial, sustainability, security and safety, and marketing performance. Table 6 lists exemplary studies that directly measure and discuss the respective performance metric.

Digital information sharing directly improves several operational performance metrics, including shorter lead time (Jiang et al., 2021; Tsamboulas et al., 2012), efficient operations (Jiang et al., 2021; Jacobsson et al., 2020), on-time reliability (Tsamboulas et al., 2012), better capacity utilisation (Fahim et al., 2021; Sun et al., 2021), enhanced traceability (Fahim et al., 2021; Tsamboulas et al., 2012; Yang, 2019), reduced organisational complexity (Ye and Wang, 2013), reduced response time (Irannezhad and Faroqi, 2021), reduced incomplete and erroneous orders (Ye and Wang, 2013), efficient recovery to normality after disruptions (Han et al., 2020), reduced inventory (Mogre et al., 2014), and improved coordination between SC partners (Irannezhad and Faroqi, 2021). In this literature review, we match the performance metrics with the relevant capabilities. The results indicate that operational performance improvement through DIS is mediated by all capabilities but mostly by integration, visibility, resilience and market sensing, and responsiveness. Most studies define and measure metrics for specific maritime organisations; in particular, at seaports, Tsamboulas et al. (2012) showed that the impact of information sharing on performance is higher for the port authority than for stakeholders, and ship anchorage time before berthing, berth occupancy rate, and annual throughput have been significantly improved. For shipping operations, the information exchange between the ship and shipping department can improve real-time on-board operations management, including optimising the ship route, fuel saving, enhancing forecasting activities and planning, and medium-to-longer term planning (Agrifoglio et al., 2017; Cristea et al., 2017). In the hinterlands, digital information sharing-based fleet management enhances fleet utilisation through shared routes (Heilig et al., 2017). Blockchain has been discussed as a technology in which operations and services are automated with efficiency (Wang and Qu, 2019; Ahmad et al., 2021), but there is an inability to predict the exact performance of blockchain owing to its early stages of maturity (Irannezhad and Faroqi, 2021).

In ports, blockchain helps customs agents, shippers, exporters, and consignees (Tan and Sundarakani, 2020) exchange information, including documental information (e.g. ship credentials, port agent records, line agent records, cargo information, custom information, and ship master record), port operational information (e.g. bill of lading (Todd, 2019), data for yard space, gate, berth availability, sea traffic, maintenance, weather), carbon reporting information and offers interconnectivity and interoperability within the network (Irannezhad, 2020).

Digital information sharing directly improves freight bill accuracy (Tsamboulas et al., 2012) and processing times of invoicing, receivables, and payment (Jiang et al., 2021). Therefore, the costs associated with financial transactions and dispute handling are significantly reduced (Jiang et al., 2021). Annual gross revenue, return on investment, and return on assets have improved, reducing the impact of risks with the DIS (Tseng and Liao, 2015; Urciuoli and Hintsa, 2021). Revenue management has been improved through electronic booking systems under ship capacity sharing agreements (Peng and Wang, 2021) and hinterland sharing agreements (Wang et al., 2021); better pricing has been achieved using information sharing (Zhong et al., 2021). The platforms discussed so far belong to partners in the SC and operate among them. Meanwhile, the third-party shipping Internet platforms can offer credit reports, disintermediation, and financial services once a substantial number of distinct shipping companies join the platform (Chen et al., 2019).

From an environmental sustainability perspective, blockchain and centralised information sharing platforms diminish almost all document-related emissions through paperless operations in maritime (Pu and Lam, 2021b). The strategic implications of market and regulation forecast sharing on sustainability investments have also been discussed (Lai et al., 2019). The results indicate that carriers' sustainability investment can be facilitated via forecast sharing. Additionally, a blockchain-based technology can support carbon reporting of SC members and facilitate carbon trading in SC. From a social sustainability perspective, social and economic ecosystem can coexist harmoniously through a social blockchain platform (Devine et al., 2021).

Table 6
Digital information sharing and categories of performance metrics.

Performance metric	References
Operational performance	Agrifoglio et al., 2017; Ahmad et al., 2021; Bavassano et al., 2020; Cristea et al., 2017; Fahim et al., 2021; Heilig et al., 2017; Irannezhad and Faroqi, 2021; Irannezhad, 2020; Jacobsson et al., 2020; Jiang et al., 2021; Mogre et al., 2014; Mondragon et al., 2017; Sarker et al., 2021; Sun et al., 2021; Tan and Sundarakani, 2020; Todd, 2019; Tsamboulas et al., 2012; Yang, 2019; Zerbino et al., 2019
Financial performance	Bavassano et al., 2020; Chen et al., 2019; Irannezhad, 2020; Jiang et al., 2021; Peng and Wang, 2021; Tsamboulas et al., 2012; Tseng and Liao, 2015; Urciuoli and Hintsa, 2021; Wang et al., 2021; Zhong et al., 2021
Sustainability performance	Lai et al., 2019; Pu and Lam, 2021b; Devine et al., 2021
Security and safety performance	Agrifoglio et al., 2017; Ahmad et al., 2021; Alkhoori et al., 2021; Chen et al., 2019; Lambrou et al., 2008; Nguyen et al., 2019; Nguyen et al., 2021; Sarker et al., 2021; Schmidt and Wagner, 2019
Marketing performance	Balci, 2021; Chung and Lau, 2006; Cristea et al., 2017; Hirata, 2019; Lai et al., 2019; Rai et al., 2006; Sun et al., 2021; Tseng and Liao, 2015

From a safety and security perspective, resilience capabilities provide powerful mediator performance. In particular, DIS platforms offer guidance to avoid ship-to-ship collisions (Agrifoglio et al., 2017) and ship-to-whale collisions in the open sea. Maritime transport is a carefully regulated mode of transport. DIS platforms also support compliance with regulations about safety and security (Lambrou et al., 2008). Ultimately, security is supported in maritime blockchain applications (Ahmad et al., 2021; Alkhoori et al., 2021; Nguyen et al., 2019; Nguyen et al., 2021) and corruption prevention schemes can be used (Sarker et al., 2021). Finally, marketing performance is highly improved through capabilities such as market sensing and responsiveness, customer relations management (Balci, 2021), and integration.

3.3. Methods and theories in digital information sharing in maritime supply chains

The examination of the methods used in our review reveals that a diverse range of methods has been adopted by scholars (see Table 7). These methods are classified into six categories: conceptual, qualitative, multi-criteria decision-making (MCDM), statistical analysis, mathematical modelling, and information technology architecture (ITA), and hybrid approaches involving at least two different methods. Conceptual papers analyse DIS without methodological application. For instance, Lambourdiere and Corbin (2020) conceptually discussed how DIS through blockchain can improve efficiency and effectiveness by adopting dynamic capabilities. Conceptual studies on DIS are particularly beneficial for understanding how complex technologies, such as blockchain, can be positioned in DIS in SCs. Qualitative studies involve interviews, focus groups, and case studies of industry members. Interviews with online shipping platform representatives (Chen et al., 2019) and multiple case studies conducted with container terminals (Mondragon et al., 2017) are examples of this category. Qualitative papers provide in-depth knowledge about managers' perceptions towards DIS, enablers of adoption, challenges of adoption, and expected or actual benefits from practical and actual usage.

The MCDM studies in our review consist of an analytical hierarchy process (AHP) (Ho and Hsu, 2020; Lam and Zhang, 2014; Zhou et al., 2020), an analytical network process (ANP) (Orji et al., 2020), and a combination of ANP and total interpretive structural modelling (TISP) (Shardeo et al., 2020). MCDM studies contribute to the DIS literature by providing numerical support regarding the level of importance of different variables or the relationships between variables. Statistical analyses in our review include regression (Hirata, 2019; Yang, 2019) and regression-based analyses, such as structural equation modelling (SEM) (Balci, 2021). Regression-based statistical analyses enable the interpretation of the level of relationships between the variables of DIS adoption or DIS-based capabilities by ensuring statistical significance. Mathematical modelling studies involve game theory-based methods and optimisation methods. These approaches mainly help decision making for operational decisions and the level of information sharing in maritime SC. ITA studies have offered conceptual architectures for DIS. Hybrid methods include a combination of content analysis and qualitative interviews (Bavassano et al., 2020; Gausdal et al., 2018), conceptual frameworks and content analysis followed by quantitative calculation (Nguyen et al., 2021; Pu and Lam, 2021b), and integration of two different quantitative analyses (Nguyen et al., 2019).

Our review results show that only eight papers design and conceptualise their research based on a theory (see Table 8). Mondragon et al. (2017) discussed TAM, institutional isomorphism, and institutional theory as potential theories to explain information communication technology adoption among container terminals, yet the main application or position of their research is not underpinned by these theories.

TAM, propounded by Davis (1989) and underpinned by the theory of reasoned action (Fishbein and Ajzen, 1975) – was utilised by three studies in our review. TAM aims to explain why a new technology is accepted or rejected by people, based on two main constructs: perceived usefulness and perceived ease of use. Hence, TAM is an ideal theory for grounding DIS adoption studies, as in the case of Yang (2019), who used TAM to measure practitioners' blockchain adoption intentions in maritime shipping. Through modifications, TAM can also be utilised in non-adoption contexts. Balci (2021), for instance, modified the statements of TAM constructs, included a digital trust construct for the model, and measured the satisfaction of freight forwarders over digitalised services of container lines.

The TOE framework is also employed as the theoretical underpinning of adoption studies. TOE is an organisational level of technology acceptance theory that aims to demonstrate factors affecting the technology adoption of organisations (Awa et al., 2017). The TOE framework suggests that the technology adoption of an organisation depends on technological, organisational, and environmental contexts (Tornatzky and Fleischer, 1990). Orji et al. (2020) used TOE to analyse blockchain adoption in the freight logistics industry, while Zeng et al. (2020) utilised TOE to study the adoption of open platforms for container bookings.

The resource-based view (RBV) is utilised by only one study which examines the relationship between integration, information technology, and firm performance in container shipping (Tseng and Liao, 2015). RBV is a competitive advantage theory indicating that resources and capabilities of firms are heterogeneous, and it is those resources that are the key for achieving and sustaining a competitive advantage (Barney, 1991; Wernerfelt, 1984). RBV is a suitable theory for explaining how DIS can lead to competitive advantage through several capabilities and performance outcomes discussed earlier in this study. A DIS can be considered a unique resource for companies in maritime SC. For instance, early adopters of blockchain-based platforms, such as AWS Supply Chains, GSBN, are expected to achieve competitive advantage (Balci and Surucu-Balci, 2021).

Table 7
Methods applied for DIS in SC.

Method	Sources
Conceptual	Lambourdiere and Corbin, 2020; Perkušić et al., 2020; Philipp et al., 2019; Pu and Lam, 2021a; Schmidt and Wagner, 2019; Todd, 2019;
Qualitative	Agrifoglio et al., 2017; Chen et al., 2019; Mondragon et al., 2017; Papathanasiou et al., 2020; Poulis et al., 2013; Sarker et al., 2021; Tan and Sundarakani, 2020; Zeng et al., 2020; Zeng et al., 2021; Zerbino et al., 2019
MCDM	Ho and Hsu, 2020; Lam and Zhang, 2014; Orji et al., 2020; Shardeo et al., 2020; Zhou et al., 2020
Statistical analysis	Balci, 2021; Hirata, 2019; Jiang et al., 2021; Tseng and Liao, 2015; Yang, 2019
Mathematical Modelling	Heilig et al., 2017; Lai et al., 2019; Li et al., 2016; Mogre et al., 2014; Peng and Wang, 2021; Sun et al., 2021; Urciuoli and Hintsa, 2021; Zhang et al., 2006; Zhong et al., 2021
ITA	Ahmad et al., 2021; Alkhoori et al., 2021; Chang et al., 2019; Chung and Lau, 2006; Cristea et al., 2017; Fahim et al., 2021; Hasan et al., 2019; Irannezhad, 2020; Irannezhad and Faroqi, 2021; Komathy, 2019; Lambrou et al., 2008; Lambrou et al., 2013;
Hybrid	Gausdal et al., 2018; Jacobsson et al., 2020; Lam and Zhang, 2014; Nguyen et al., 2019; Nguyen et al., 2021; Pu and Lam, 2021b; Tsamboulas et al., 2012

Table 8
Theories adopted in sampled articles.

Theory	Sources
Resource-based View (RBV)	Tseng and Liao, 2015
Technology Acceptance Model (TAM)	Balci, 2021; Tan and Sundarakani, 2020; Yang, 2019
Technology-Organisation-Environment (TOE)	Orji et al., 2020; Zeng et al., 2020
Transaction Cost Economics (TCE)	Irannezhad, 2020; Schmidt and Wagner, 2019

Transaction cost economics (TCE) is utilised by two studies in our review. Irannezhad (2020) utilised TCE to explain the value propositions of port logistics transactions through blockchain. In contrast, Schmidt and Wagner (2019) discussed the relationship between supply chains and blockchain through the lens of TCE theory. TCE is ideal for a theoretical background to benefits achieved through DIS, as the theory is concerned with the optimum governance structure to achieve economic efficiency by minimising the cost of transactions (Williamson, 1979), and DIS platforms can minimise fragmented logistics transactions, thereby reducing the total cost.

Considering the methods and theories in the DIS literature, we acknowledge that these methods significantly contribute to understanding DIS in SC. ITA studies, for instance, play a key role in understanding how DIS can function, such as the architectural illustration of how smart contracts and the IoT can be operated for real-time information sharing of vaccine transportation in containers (Alkhoori et al., 2021). Qualitative empirical studies also play a key role in gaining a deeper understanding of real-life adoption situations and managers' opinions on DIS. However, qualitative papers need to be complemented by quantitative research for numerical support.

Empirical quantitative studies establish numerical support for demonstrating practitioners' perceptions regarding the adoption of DIS and the benefits they expect or actually receive from DIS. For instance, AHP, the most common MCDM technique in our sample, is utilised to determine the most important factors affecting the adoption of DIS. However, the complex interrelationship between DIS, barriers and enablers, and outcomes compels more advanced techniques to reveal these relationships. ANP, only applied in two papers, and TISP, only applied in one paper, are more appropriate than AHP to investigate these relationships.

Statistical empirical studies can also numerically reflect practitioners' opinions and implementation. Moreover, relationships between variables in causal statistical studies are based on statistical significance confirming that relationships between variables do not occur randomly or by chance (Benjamin et al., 2018). SEM studies are particularly appropriate when considering the complex relationships in the DIS context. For instance, DIS implementation as a construct can be an exogenous and endogenous variable simultaneously, because its application might be affected by several barriers and enablers while simultaneously affecting several capabilities and performance outcomes at the same time. Another potential construct, such as supply chain integration, which depends on the successful execution of DIS and affects the operational performance outcome, can be both exogenous and endogenous variables. SEM, in which a variable can be both exogenous and endogenous simultaneously, is an ideal method for investigating such relationships, yet only three of the sampled articles have applied this method (Balci, 2021; Jiang et al., 2021; Tseng and Liao, 2015).

4. Future research directions

Our findings are comprehensive, as we reveal various variables as enablers and barriers of DIS, capabilities that can be created through DIS, and performance outcomes that can be improved by the mediation of capabilities generated by DIS or the direct impact of DIS. The breadth of the variables gives rise to numerous research models that can be tested. Our study presents future research directions in two major domains: DIS adoption in maritime SC, and the role of DIS in supply chain capabilities and performance. Our review reveals the lack of empirical studies on DIS in maritime SC, despite their necessity. Hence, our methodological focus is on empirical elements focusing more on quantitative research.

Potential research direction I: Digital information sharing adoption in supply chains.

The importance of exploring DIS adoption has been proven by the case of Tradelens, the blockchain platform which was initiated by IBM-Maersk but failed to continue its operations because of lack of adoption from the industry at global scale (Reuters, 2022). Our review reveals that DIS adoption is a complex issue that involves various intra- and inter-firm barriers and enablers. On the one hand, DIS adoption depends on a rational perspective that aims to maximise utilisation through enablers, such as cost reductions and efficiency gains. On the other hand, it is affected by irrational attitudes, such as managers' conservatism, despite proven benefits. Adoption presents complex challenges in terms of organisational- and individual-level perspectives. The lack of knowledge towards technology at the individual level and the lack of human resources at the organisational level affect DIS adoption. Moreover, adoption depends on the characteristics of DIS platforms, such as their cost and the regulations that govern these platforms.

The complexity of DIS adoption compels future research to evaluate different information system theories, possibly a combination of them. TAM and TOE are independently utilised as underpinning theories in the state-of-the-art, yet future studies should consider their complementary roles to accommodate the complexity of DIS adoption better. For instance, the literature confirms the suitability of TOE at the organisational level of technology adoption in the supply chain and logistics domains (Lin, 2014; Orji et al., 2020; Tian et al., 2021). However, TOE does not consider individual factors such as perceived benefits (Awa et al., 2017). The findings of our review also verify these shortcomings, as some of the revealed enablers do not fall into the category of TOE frameworks. For instance, reduced cost, reduced lead time, increased transparency, and increased traceability are the enablers that should be measured considering the perception of individuals. In this sense, TAM offers an ideal theoretical background as it explains the intention to use a technology based on perceived usefulness and perceived ease of use. Therefore, the combination of TAM and TOE should be considered because of their complementary role in underpinning the complex adoption of DIS.

The sections on barriers and enablers (Sections 3.2.1 and 3.2.3) reveal the interdependencies between variables. For instance, the lack of knowledge about DIS platforms can lead to conservatism, which can cause a lack of support from stakeholders and can lead to lack of scalability. The trust and privacy concerns and lack of regulations can also affect these barriers and get affected by them. Future studies should investigate the most influential barriers or root causes that generate other barriers, as well as their inter-relationships. Interpretive structural modelling (ISM), which utilises expert opinions to uncover the interrelationships between variables and transforms unclear interpretive models into visible structures, can be a useful method for examining the most influential barriers.

Our review illustrates the importance of individual-level factors in adoption, such as conservatism, trust, and a lack of knowledge. However, none of the empirical studies has focused on individual perceptions and factors affecting their attitudes towards DIS. Hence, future studies can investigate managers' individual-level perceptions of managers towards DIS to scrutinise potential reasons for their conservatism. Qualitative studies are ideal for such studies because they can offer an in-depth understanding of complex and abstract concepts such as trust and conservatism. For instance, similar to Roberts et al. (2021) who study psychological factors of technology adoption in oil industry, physiological factors affecting DIS adoption can be studied through in-depth interviews with managers from different segments of the maritime SC to reveal why and how DIS adoption faces against conservatism by managers. In this regard, multidisciplinary studies in collaboration with other disciplines, such as psychology and information systems, may help to discover unique individual characteristics of practitioners towards DIS adoption.

Effective promotion of DIS requires leading stakeholders to develop customised promotion tools based on the characteristics of different groups of practitioners. The case of Tradelens failure has proven the importance of promoting DIS platforms to different members of maritime SC through a customised approach. The Tradelens blockchain platform was adopted by a significant number of ports and some key

custom authorities around the globe, yet it has failed to attract beneficial cargo owners who are the customers in maritime SC (Balci and Surucu-Balci, 2021). Future research should, for instance, address the question of why Tradelens has attracted ports but not cargo owners. The future research could also investigate the interaction between those actors in terms of adopting a DIS platform. An institutional theory perspective could be utilised to examine how behaviours of different actors are influenced by the leading organisation.

The disclosure of individual-level motivations for DIS adoption may help leading stakeholders in DIS to better promote it to industry practitioners. Perceived usefulness of DIS platforms should be explored in a more granulated level by investigating different members of maritime SC such as forwarders, container lines, shippers, hinterland and trucking companies. Distinct groups of decision-makers can be identified by a segmentation study based on perceived usefulness or barriers using a cluster or decision-tree classification method.

The segmentation approach can be applied at the organisational level to reveal the enablers of DIS that are more important for different members of the SC. For instance, ports/terminals may attach more importance to having connected supply chains, while shippers may prioritise reduced lead time. Shippers also differ in the capabilities they seek, and different segments exist among them (Balci and Cetin, 2020). For instance, a retailer may pay more attention to the visibility capability of DIS, while a basic material exporter may prioritise the cost reductions that DIS brings. Heterogeneity and distinct segments are evident among freight forwarders (Wen and Lin, 2016). Thus, a micro-analysis of the industries of different members can be conducted. Future research can also follow a more granulated approach regarding the type of DIS platforms and the usage purpose of actors. For instance, cargo owners' adoption attitude to DIS may vary if it is used for electronic bill of lading or cargo booking, or it is used as a container line's in-house platform or an industry-wide platform like GSBN.

Potential research direction II: The role of digital information sharing in dynamic capabilities and performance outcomes.

As discussed in Section 3.2.3, the dynamic capabilities view, originating from the resource-based view and contingency theory, can be a useful underpinning theory. A large number of dynamic capabilities and performance outcomes are revealed in our review, which offers numerous opportunities for SEM analysis in future research. Our review suggests that DIS can directly affect performance metrics. This is in line with supply chain literature which indicates the direct impact of information sharing on sustainability (Khan et al., 2018), financial performance (Sahin and Topal, 2019), operational performance (Chen et al., 2019), and marketing performance, such as customer responsiveness (Ye and Wang, 2013). A direct positive impact is also expected with DIS, considering how companies' operations, marketing, and business processes become digitised in the shipping and port industry (Balci, 2021).

The impact of DIS on performance metrics should be tested in future studies to validate these propositions, as the literature lacks a statistical analysis on the impact of DIS. Measuring the relationship between DIS and security and safety performance can fill an important gap in the literature, as this is an overlooked performance metric which is becoming more relevant considering how supply chains have been disrupted by political tensions such as the Russia-Ukraine war and the increasing number of cyber-attacks and disasters due to climate change (Hodgson, 2022). The impact of DIS on performance should be studied in different industries and countries, as significant differences exist in terms of adoption between industries, superstructure, and infrastructure for DIS between countries (Gal et al., 2019).

The impact of a DIS on performance metrics can also be mediated through dynamic capabilities. In other words, DIS may not have a direct impact on some performance outcomes, but it can have an indirect impact through a mediator capability. For instance, the impact of supply chain integration on different performance metrics has been corroborated by several studies, including sustainability, operational performance, and marketing (Ganbold et al., 2020; Kang et al., 2018). DIS may not directly impact sustainability performance but can have a positive indirect effect through the mediation of supply chain integration. A similar situation may exist with resilience as a mediator between DIS and financial performance. DIS may not necessarily improve financial performance indicators, such as return on investment and profit. However, it can have an indirect effect through the mediation of resilience which has a direct positive impact on financial performance (Yu et al., 2019).

We present an exemplifier conceptual framework that can be utilised in a future SEM study as shown in Fig. 4. A future study can test the impact of DIS on integration, resilience, operational performance, and financial performance while measuring the mediating role of integration and resilience between DIS and performance outcomes. It is highly likely that positive relations can be observed between capabilities, e.g., integration affecting resilience, and between performance outcomes, e.g., operational affecting financial performance. Conducting such study can illustrate the broader role of DIS in a supply chain context.

Another perspective that can be adopted in future studies is the use of the DIS as a moderator. Information sharing has been tested as a moderator in the supply chain management literature (Lin et al., 2022). However, the role of digital information sharing as a moderator should be examined by future papers. A moderator modifies the strength or direction of relationship between variables, and the moderation effect explains "when" an independent variable causes a dependent variable (Wu and Zumbo, 2008). In the DIS context, it refers to measuring whether a capability causes a performance outcome when DIS is utilised. For instance, DIS implementation can moderate the relationship between customer relationship management and marketing performance, as customer relations can have a stronger impact on overall marketing performance if information is shared in real time through digital platforms.

5. Conclusion

The main purpose of this study is to provide a systematic literature review to understand the set of capabilities, enablers, and barriers, their relationships, and contributions to each performance metric attached to digital information sharing in maritime supply chain management. Our systematic literature review included 59 peer-reviewed academic articles. The first objective of the study is to identify enablers and barriers to DIS adoption and discuss their relationships. Our review identify eight main barriers to DIS implementation in maritime SC based on the TOE framework. These barriers include adoption costs, scalability and infrastructure, conservatism, lack of human resources, lack of knowledge, trust and privacy concerns, lack of regulations, and lack of stakeholder support. The enablers identified in our study include security, traceability and trackability, transparency, connected supply chain, environment, reduced lead time, reduced costs, paperless trade, and efficient information sharing.

The second objective of the study is to reveal which SC capabilities and performance outcomes that can be improved via the implementation of DIS in maritime SC. Our review uncovers six DIS-powered capabilities: integration, resilience, visibility, optimisation, market sensing, and customer relationship management. Our study also reveal that DIS implementation can improve operational, financial, sustainability, safety, security, and marketing performance either directly or through the mediation of SC capabilities.

The third objective in our paper is to uncover the theories and methods used in literature. Our study reveal, most studies lack a theoretical background. This result is in line with the findings of Zhu et al. (2022), who underlined the atheoretical research on blockchain studies in SC. Our review also found out that only a few studies have adopted quantitative empirical research methods. In particular, there is a significant gap in empirical studies examining causality. Future research directions are suggested, considering these gaps in relation to the barriers, enablers, capabilities, and outcomes discovered in our review.

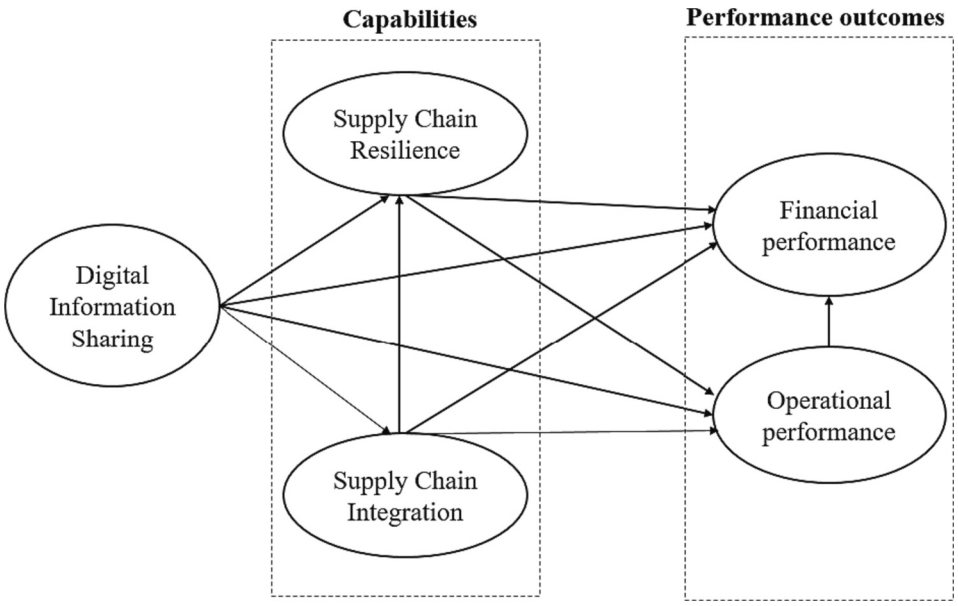

Fig. 4. An exemplifier conceptual framework for a future SEM study.

This study contributes to the literature by adopting a holistic approach and uncovering both enablers and barriers to DIS adoption, capabilities built by DIS, and performance outcomes improved through DIS implementation. This holistic approach allows readers to obtain a comprehensive understanding of DIS in maritime SC and relates all components and use cases. The comprehensive analysis illustrates different variations of research questions and models that can enrich causal empirical research in the domain of DIS in the SC. Our future research directions will present potential relationships to be analysed. The authors can also examine the potential constructs that we have revealed and discover other relationships in future studies.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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