ABSTRACT

COVID-19 has recently affected global trade flows, and the primary reason is that shipping failed to adapt rapidly to meet the need for on-time delivery. Given blockchain’s “revolutionary” potential, this paper aims to understand how blockchain can address longstanding inefficiencies and challenges in the shipping industry. This analysis proposes a model of how an industrywide blockchain-based consortium powered by smart contracts could resolve end-to-end contract issues with trustworthiness, thus improving efficiency in terms of time and cost. A mixed-method approach was conducted. That included 27 surveys and 20 interviews with representatives of shipping industry members. This study contributes to the blockchain and shipping supply chain literature by offering empirical data about the application of an industry-led consortium blockchain with cost, scalability, and volatility perspectives. As for the managerial implications, incentives and education are required to stimulate collaboration and commitment to blockchain for more efficient and effective global shipping trade flows.

KEYWORDS
Blockchain, Information Systems, Shipping Industry, Smart Contracts

INTRODUCTION

Since blockchain expands beyond cryptocurrency transactions, practitioners have extensively explored it (IBM, 2017). For example, information system (IS) researchers have studied the various applications of blockchain across many different fields, including finance, energy, supply chain, health, and media (Berdik et al., 2021), and many issues, including privacy and data management (Casino et al., 2019). Such extensive research is due to blockchain’s “revolutionary” potential (Gomber et al., 2016). It provides innovative solutions to businesses with unprecedented trustworthiness, transparency, and traceability (Concensys, 2020). In supply chains, organizations incorporating blockchain technology can increase disintermediation, which means that suppliers can transact directly with customers, efficiently track products, assure data integrity, negate the need for reconciliations, and track products efficiently (Lacity, 2018).

Many studies consider logistics and supply chains as ideal scenarios, known as the current blockchain trends (Buthelezi et al., 2022) as blockchain can offer more benefits than the traditional approaches (Iansiti & Lakhani, 2017). Most importantly, authors argue this is the new technology that
can address these challenges (Sultana et al., 2022). Costs would be reduced in the supply chain due to disintermediation, as blockchain eliminates agents’ or intermediaries’ requirements. The monetary settlements would also be automated to show that the conditions detailed in the smart contract are fulfilled, and the goods/services are delivered (Hughes et al., 2019). Hence, supply chains have received much attention for blockchain application research (Buthelezi et al., 2022).

Globally, almost 90% of the world’s goods are seaborne (International Chamber of Shipping, 2022). Hence, bulk maritime transportation plays an essential role in the worldwide economy (Transparency Market Research, 2020). However, the COVID-19 pandemic has affected global trade flows at an unprecedented speed and scale, primarily due to supply-chain actors’ inability to adapt rapidly (UNCTAD, 2021). Simply put, maritime shipping failed to meet the need for on-time, faster deliveries and the traceability and transparency of their shipments (Shou et al., 2021).

Moreover, transparency and traceability have recently become even more evident in global shipping supply chains following several disruptions, such as COVID-19 and empty container issues (Masudin et al., 2021). Issues of unreliable schedules, port congestion, no-shows, and rollovers have further complicated the shipping supply chain (Song, 2021). The challenge is the interaction between the cargo carriage from the suppliers to the receivers. Traditionally, these parties’ interactions have been governed by a “Charter Party” contract agreement. Typically, executing this type of contract involves three steps: (1) connecting and matching cargoes with ships, (2) negotiating with both charterers and shipowners, and (3) making calculations and payments.

Significant impediments in this process are that an agreement is signed only after mutual trust is formed, evidence that the obligations in a contract are met, and payment transfer obligations are secured through the banks. Unfortunately, the lack of trust between parties and this industry’s extremely high fragmentation (Song, 2021) drove up the coordination costs of international trade and ultimately impeded them (Li & Zhou, 2021; Bavassano et al., 2020).

Until now, the global shipping industry has been slower than most in adopting emergent technologies to expedite the shipping processes (Cargo Shipping International, 2020). The industry lacks accuracy, reliability, transparency, and visibility (Song, 2021). Although physical documents are best for preventing fraudulent activities, many problems are worth investigating, especially the shipping industry’s culture and business processes (Tirschwell, 2017).

So far, many shipping supply chains have been caught up in the massive volume of documents shuffled among intermediaries (Li & Zhou, 2021). Information sharing between shipping and supply-chain organizations has relied heavily on inefficient and error-prone manual processes (Li & Zhou, 2021). Thus, finding the right match in this highly fragmented supply chain (Song, 2021) using multiple communication platforms, brokers, and intermediaries further complicates and delays the processes.

Given all these challenges, many shipping and port operators have tested the possibility of exploiting blockchain (Bloomberg, 2018). Among these, several blockchains were introduced by Maersk and IBM for the shipping industry (Bavassano et al., 2020) to solve the shipping industry’s issues. But historically, this industry will only invite innovative solutions if they can generate clear financial advantages (Stopford, 2009). Until today, technological and technical advancements in the shipping industry have always been challenging due to a certain conservativism (Bavassano et al., 2020).

Interestingly, with all the ongoing challenges and interest in blockchain in the shipping supply chain, very little research has been done on blockchain at the container terminals (Song, 2021), and not many studies are currently assessing the implementation of blockchain in the shipping business (Bavassano et al., 2020). Since it is essential to digitalize all aspects of the logistics segments in the shipping supply chain (Song, 2021), this research aims to fill the gap by exploring how blockchain can make this shipping process more efficient in time and costs. Given that blockchain technology’s new costs and risks should be well-estimated and assessed (Li & Zhou, 2021), we further address this need by constructing a scenario using Ethereum blockchain data to analyze the potential cost and time savings in liquid bulk maritime shipping.
This paper is organized as follows. First, the authors indicate the research motivation and purpose in the Introduction. Second, paper provides an overview of a consortium blockchain to improve shipping efficiency. Finally, paper discusses the research methods, followed by data analyses and conclusions.

**BACKGROUND: CONSORTIUM BLOCKCHAIN TO IMPROVE SHIPPING EFFICIENCY**

In line with the technology field’s emergent nature (Beck et al., 2016), the blockchain literature reveals several main research streams in an attempt to make sense of its implications for organizations and society and its position in the information systems (IS) discipline. The first stream of research focuses on blockchain’s technical dimensions (how it works) and issues such as security and proof-of-work (Gervais et al., 2016). This work tilted toward IS and computing disciplines (Gervais et al., 2014; Glaser, 2017) and focuses on the design of blockchain solutions in the supply chain (Yong et al., 2020).

The second stream of research focuses on demonstrating the applications of blockchain, either conceptually or through the development and evaluation of blockchain-based applications (Beck et al., 2016; Parra-Mayono & Ross, 2017).

These studies have contributed to an understanding of the range of applications and value systems; for instance, how blockchain enables otherwise unsustainable social business models (Schweizer et al., 2017) and enables “trust-free” rather than “trust-based” transaction systems (Beck et al., 2016; Parra-Moyano & Ross, 2017).

Researchers explore the potential of blockchain in a range of contexts. For instance, supply chain traceability (Masudin et al., 2021), marketing (Jain et al., 2021), insurance (Kar, 2021), social media (Tandon et al., 2021), business (Frizzo-Barker et al., 2020), health care (Kumari & Saini, 2020), and government (Allen et al., 2019). Importantly, this second stream also identifies scalability issues, costs, and volatility as continual challenges (Beck et al., 2016). This stream of research corresponds with this research that takes a practical lens to understand blockchain’s value and cost savings.

The third stream of research attempts to map out the current literature and propose directions for future research. Similar reviews have been undertaken in adjacent fields by focusing on the technical (Conoscenti et al., 2016; Tama et al., 2017) and financial aspects of the blockchain (Zhao et al., 2016), as well as providing general overviews (Yli-Huumo et al., 2016).

In their review, Risius and Spohrer (2017) identified three areas for future IS research: (1) design issues, which focused on questions around the affordability of features and the interactions between them in smart contracts and systems; (2) measurements and values focused on blockchain’s social and economic impacts; and (3) management and organizations focused on blockchain’s implications for organizations’ operations. Other authors have mapped the blockchain landscape by tapping into the mainstream media to understand how it frames blockchain (Zavolokina et al., 2016).

Blockchain offers a distributed peer-to-peer ledger comprising an ordered set of connected and replicated data blocks (Dresher, 2017). This distributed database records transactions between parties and records are written into immutable and permanent blocks (Iansiti & Lakhani, 2017). A blockchain is an immutable audit trail where each block’s “DNA” is incorporated, making it impossible to alter history without noticing the attempt to do so (Catalini & Gans, 2016). Such an application could potentially improve business transaction speed for ocean shipping. Blockchain decentralizes peer-to-peer data structures that can record and store data on multiple computers across the networks to ensure that all parties agree to a single truth and that the recorded data is immutable. In doing so, the benefits from network effects and shared digital infrastructure do not come at the cost of increased market power and data access by an intermediary (Catalini, 2017).

Consortium blockchain—a “semi-private” blockchain with a controlled user group that works across different organizations—has found a few banking and supply chain management applications. The need for trustworthy information is important to perform activities successfully (Ada et al.,
2021). However, in such settings, there is a limited set of mutually mistrusting entities that want to interact and change the state of a system, but they are unwilling to agree on an online trusted third party (Wust & Gervais, 2017).

A blockchain is ideal for a platform that provides electronic transactions without relying on trust between the transacting parties (Nakamoto, 2008), which could resolve the challenge of reaching an agreement among multiple members in an extensive system (Jiang, 2017). Furthermore, this technology allows a network of agents to agree, at regular intervals, on the actual state of their shared data. Therefore, there is no need to publicly verify the information related to a shipping contract. For example, Walmart and Maersk have successfully piloted IBM consortium blockchain solutions to trace food (Gagliordi, 2018). IBM Food Trust has more than 280 members, 40 million transactions, and 25,000 SKUs (Lacity & Hoek, 2021).

So far, blockchain has been discussed in specific shipping markets (Gausdal et al., 2018; Allen et al., 2019). Some have investigated the impact of blockchain on specific shipping segments, such as container terminal handling operations (Hafizon et al., 2019), but only a few studies have focused on the blockchain with a specific way to achieve greater efficiency (Tan et al., 2018). Thus, this study focuses on how blockchain can address longstanding inefficiencies and challenges in the shipping industry.

A smart contract is a computer program that runs on a blockchain. Its correct execution is enforced by the consensus protocol of that blockchain (Szabo, 1997). This software code stores all necessary instructions on the blockchain and executes them on its own when the set parameters are met (Swanson, 2015). It can also be automated in response to future events, which adds substantial flexibility to the verification process. In addition, contracting parties can agree on the rules for an audit, thereby reducing the need for dispute resolution if a problem emerges.

Smart contracts can run on a public or permissioned blockchain and have wide applications in any industry where contracts are used. For example, suppose a buyer and a seller agree to different terms based on the weather conditions. In this case, a smart contract could aggregate information from multiple weather sources (including sensors) to adjudicate a dispute (Catalini, 2017). Since the contract is stored on the blockchain, it is immutable and undeniable. Hence, the two parties can enter into a contract agreement without brokers or intermediaries, or without trusting each other. A smart contract can also be coded to follow a pre-defined recourse if it encounters a specific error, such as a mismatch in data from different sources. The researchers explore its application in various stages of the shipping contract process with these possibilities.

Shipping markets, particularly the bulk ocean-freight markets, suffer from temporal specificities because of the time and space (location) factors. This leads to haggling between the shipper and the carrier over the hire rates (Pirrong, 1993). Worse, the fees paid to the intermediaries and brokers are usually not justifiable (Kapnissis, Leligou, & Vaggelas, 2020). The cost is exacerbated when the brokers or intermediaries gain market power, often resulting from an information advantage (Stiglitz, 2002, cited by Catalini, 2017). To address this challenge, the researchers believe smart contracts can be used to execute a charter party agreement to calculate hire and demurrages based on a pre-defined formula, including initiating a fund transfer between the charterer and the shipowner. Furthermore, all these transactions can be done directly using the blockchain’s consensus mechanism (Letourneau & Whelan, 2017). Thus, the use of brokers and intermediaries can be eliminated.

**METHODOLOGY**

This study adopts a mixed-method approach (Venkatesh et al., 2013), including a survey and interview and building of scenarios to apply a blockchain consortium to resolve end-to-end shipping contract issues with trust and to improve efficiency in time and cost. The mixed-method approach builds on qualitative and quantitative methods within the same research inquiry (Venkatesh et al., 2013). This approach provides more robust inferences than a single method (Teddlie & Tashakkori, 2009), thus
it is appropriate for this applied research, which is grounded in the global shipping industry supply chain. Given its complex phenomenon that includes participants from different companies, a single method would not be enough to capture its rich and complex insights (Behrendt et al., 2014). Thus, a mix-method is necessary to yield sophisticated insights and improve the results validity through triangulation from different sources of evidence (Pee et al., 2020). Refer to Figure 1 for the mix method strategy.

**Data Collection**

Data collected focused first on mapping and understanding the contracting process in the shipping industry. To identify the existing problems and the scope for practical contributions and improvements, this study taps into the researcher’s 18 years of experience in the shipping industry, supported by a research survey designed mainly to understand the problems faced by the industry professionals and issues raised in literature reviews (Li & Zhou, 2021, Stiglitz, 2002, as cited by Catalini, 2017).

All 27 initial respondents were approached based on purposeful sampling. Respondents were identified by the researchers based on their industry contacts. They were selected based on the shipping executing process incorporating the three main stakeholders: shipowners, charterers, and shipping executives. They were the key decision-makers or senior executives with at least 10 years of working experience in the shipping industry. After responding to a survey or interview, they were approached to refer other potential respondents of a similar caliber who could offer rich information about the phenomenon of interest (Palinkas et al., 2015). The first author sent an email invitation to his shipping industry network for referrals. If a participant was interested, they would reply to the email to either conduct a survey or set up a face-to-face interview.

All 27 survey respondents—16 brokers, 3 shipowners, and 1 charterer— (refer to the Appendix for survey questions) (refer to Table 1 for respondents’ profiles). They have proven to be phenomenally relevant within their respective areas during the data collection as evidenced by challenges encountered throughout the years in their business, making them revelatory respondents for this study (Gerring, 2008).
The researchers followed up with 20 one-to-one interviews (refer to their interview profiles) to understand this study’s phenomenon (refer to the Appendix for sample questions) and map up the contracting process issues. Each interview session lasted from 40 minutes to 60 minutes. The author took notes during the interviews using a laptop as many informants were not comfortable with the sessions being recorded. Only a few interview sessions were recorded (see Table 2).

| No. of Informants | Job Title                          | Role          | Years of working experience in the Shipping industry |
|-------------------|-----------------------------------|---------------|-----------------------------------------------------|
| Informant 1       | Senior Executive                  | Broker        | 15-25                                               |
| Informant 2       | Shipbroker                        | Broker        | 15-25                                               |
| Informant 3       | Manager, Tanker Chartering & Gas Project | Broker  | 10-15                                               |
| Informant 4       | Operations Superintendent          | Ship-owner    | 10-15                                               |
| Informant 5       | Chartering Specialist             | Broker        | 15-25                                               |
| Informant 6       | Tanker Chartering Manager         | Broker        | 15-25                                               |
| Informant 7       | CEO                               | Broker        | 15-25                                               |
| Informant 8       | Senior Manager                    | Ship-owner    | 15-25                                               |
| Informant 9       | Director                          | Charterer     | 15-25                                               |
| Informant 10      | Partner                           | Broker        | 25+                                                 |
| Informant 11      | Operations Manager                | Ship-owner    | 10-15                                               |
| Informant 12      | General Manager                   | Broker        | 15-25                                               |
| Informant 13      | Founder and Managing Director     | Broker        | 15-25                                               |
| Informant 14      | Shipbroker                        | Broker        | 15-25                                               |
| Informant 15      | Chartered Shipbroker              | Broker        | 15-25                                               |
| Informant 16      | Consultant                        | Broker        | 25+                                                 |
| Informant 17      | Operations Manager                | Broker        | 15-25                                               |
| Informant 18      | Senior Manager                    | Broker        | 15-25                                               |
| Informant 19      | Manager, Chartering               | Broker        | 15-25                                               |
| Informant 20      | Senior Manager                    | Broker        | 15-25                                               |

Table 1. Survey of respondents’ profiles

Table 2. Interviewees’ details

| No. of Informants | Job Title                          | Role          | Years of working experience in the Shipping industry |
|-------------------|-----------------------------------|---------------|-----------------------------------------------------|
| Informant 1       | Senior Executive                  | Broker        | 15-25                                               |
| Informant 2       | Shipbroker                        | Broker        | 15-25                                               |
| Informant 3       | Manager, Tanker Chartering & Gas Project | Broker  | 10-15                                               |
| Informant 4       | Operations Superintendent          | Ship-owner    | 10-15                                               |
| Informant 5       | Chartering Specialist             | Broker        | 15-25                                               |
| Informant 6       | Tanker Chartering Manager         | Broker        | 15-25                                               |
| Informant 7       | CEO                               | Broker        | 15-25                                               |
| Informant 8       | Senior Manager                    | Ship-owner    | 15-25                                               |
| Informant 9       | Director                          | Charterer     | 15-25                                               |
| Informant 10      | Partner                           | Broker        | 25+                                                 |
| Informant 11      | Operations Manager                | Ship-owner    | 10-15                                               |
| Informant 12      | General Manager                   | Broker        | 15-25                                               |
| Informant 13      | Founder and Managing Director     | Broker        | 15-25                                               |
| Informant 21      | Managing Director                 | Ship-owner    | 25+                                                 |
| Informant 22      | Technical Superintendent           | Ship-owner    | 25+                                                 |
| Informant 23      | Technical Superintendent           | Ship-owner    | 25+                                                 |
| Informant 24      | Operations Superintendent          | Ship-owner    | 15-25                                               |
| Informant 25      | General Manager                   | Charterer     | 15-25                                               |
| Informant 26      | Operations Manager                | Charterer     | 15-25                                               |
| Informant 27      | Director                          | Broker        | 25+                                                 |
Field observations and secondary data were used to supplement these interviews. These data provided depth to research inquiry by providing deeper insights (refer to Table 3).

To address a certain conservativism in the shipping industry (Bavassano et al., 2020) and the need for data on the costs and risks that come with blockchain use (Li & Zhou, 2021), Ethereum blockchain data were incorporated to analyze the potential costs and time savings to justify the proposed solution.

**DATA ANALYSIS**

The researchers used the initial survey data to divide the events, activities, and decisions during the three shipping executing contract processes with interview data before the authors confirmed empirical findings with scenario data from the July 2021 Ethereum Blockchain.

The preliminary survey data were analyzed using Excel and presented using Tableau, which offers better visualization.

Survey data were triangulated with the one-to-one interview. Authors used open, axial, and selective coding tactics (Strauss & Corbin, 1998). The data were transcribed via manual-open coding (refer to the Appendix) before using manual mental coding with sticky notes. Then, the data were further segmented using an electronic method with the keyword search. The created categories were later segmented and coded using an Excel spreadsheet (refer to the Appendix). Then each analysis was compared and critically reviewed to achieve inter-coder reliability after numerous reiterations in fine-tuning before deriving the conceptual framework. Ultimately, data were corroborated to ensure validity. Data reiteration continued with several follow-up interviews lasting another few months until the findings reached theoretical saturation. No new or contradictory themes emerged through newly collected data (Eisenhardt, 1989). Finally, to provide practical solutions to resolving issues identified from the surveys and interviews, the authors used Ethereum blockchain data to calculate the potential cost before providing informed solutions and recommendations.

| Internal validity | Researcher conducted field observation and triangulated survey data with interviews and field observations. |
|-------------------|----------------------------------------------------------------------------------------------------------|
|                   | Debriefing was done among researchers to validate further the credibility of the data collected.          |

| External validity | Variables used were generated from literature (refer to appendix 3, for example). |
|-------------------|----------------------------------------------------------------------------------|
|                   | Survey holds variation in settings, and interviews were conducted to map the cause-effect relationships to understand the contracting process and identify problems. |

| Reliability       | Data was gathered using purposive sampling via survey and interviews for test-retest reliability. |
|-------------------|-------------------------------------------------------------------------------------------------|
|                   | Informants’ confidences were protected so that they could share rich insights without reservations. |

| Objectivity       | With survey data collected as the 1st order of findings, we conducted interviews to gather 2nd order findings to confirm that the information obtained was accurate and reliable. |
|-------------------|---------------------------------------------------------------------------------------------------|
|                   | Interview data were carefully transcribed, with observation notes recorded.                       |

Table 3. Techniques to ensure the trustworthiness of research in quantitative and qualitative research (based on Lincoln & Guba, 1985; Shah & Corley, 2006; Venkatesh et al., 2013)
To better understand how blockchain can make this shipping process more efficient in terms of times and costs, this study breaks the analysis section into two main sections. First, to understand the longstanding inefficiencies and challenges in the shipping industry, the researchers collected data to cover the entirety of the three contracting steps: (1) connect and match cargoes and ships, (2) negotiate with charterers and shipowners, and (3) calculate and pay. These findings are presented in sections 4.1 to 4.3.

Second, to address the shipping industry issues (Bavassano et al., 2020) and offer better cost estimation (Li & Zhou, 2021), Ethereum public blockchain data from July 2021 was adopted. This helps illustrate Blockchain’s potential costs and efficiencies in Section 4.4.

**Step 1: Connect and Match Cargoes With Ships**

At this step, charterers and shipowners look for each other and pass on their details to brokers, usually communicating through emails and phone calls. Both parties will provide information such as cargo type, quantity, date a ship is required, and the port where the ship is needed, so the broker can help find a match to connect them. However, even though the need for transparency and traceability has become more evident in this industry (Masudin et al., 2021), according to respondents, it still took a minimum of one to four days for the cargo to find the matching ship:

The difference in time zones sometimes makes communication challenging. By the time Hong Kong opens, most of Europe is already preparing for bed. Negotiations take longer than usual, although people do work round the clock in most cases. (Informant 3, manager, tanker chartering and gas projects)

Since the charterer and shipowner mostly do not know each other, the trust between parties was weak (Li & Zhou, 2021; Bavassano et al., 2020), so informants had to rely on brokers to find the right match. As a result, it takes both parties three to 10 days, with a median of seven days, to find a match and place a vessel for port authorities’ approval (see Figure 2 for the result obtained from questions 1 to 3):

Market conditions dictate the speed at which different parties respond, but over a long period, as the markets go in cycles, these factors are balanced out. (Informant 21, managing director)

The box plots show each question’s minimum, first quartile, median, third quartile, and maximum values. Data points above 1.5 times the inter-quartile range (IQR) are treated as outliers. For example, the plot for the first question shows that it took a minimum of a day to complete finding the correct

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**Table 4. Linking data analysis with the survey, interview questions, and Ethereum blockchain data**

| Data analysis sections | Shipping executing contract processes with Survey Data | Interview Data and Ethereum Blockchain data |
|------------------------|-----------------------------------------------------|-----------------------------------------------|
| Section 4.1 and 4.2    | Step 1: Connect and match cargo with ship data Step 2: Negotiation between charterer and shipowners Step 3: Calculations and payments | Interview Data |
| Section 4.3            | Scenario Data from July 2021 Ethereum Blockchain | Ethereum Blockchain Data |

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**FINDINGS**

To better understand how blockchain can make this shipping process more efficient in terms of times and costs, this study breaks the analysis section into two main sections. First, to understand the longstanding inefficiencies and challenges in the shipping industry, the researchers collected data to cover the entirety of the three contracting steps: (1) connect and match cargoes and ships, (2) negotiate with charterers and shipowners, and (3) calculate and pay. These findings are presented in sections 4.1 to 4.3.

Second, to address the shipping industry issues (Bavassano et al., 2020) and offer better cost estimation (Li & Zhou, 2021), Ethereum public blockchain data from July 2021 was adopted. This helps illustrate Blockchain’s potential costs and efficiencies in Section 4.4.
ship. The larger box indicates a broader spread of responses for the second question. The inner quartile range is from 3 to 10 days, with a median of 7 days.

The most common tender times are presented in Figure 3. A triangle probability distribution shows that the tender process would take one day to a month to put a ship on hire. This also drove international trade coordination costs and impeded global trade (Li & Zhou, 2021; Bavassano et al., 2020).

The above triangular distribution is a continuous probability distribution plot based on the probability density function. The two ends of this triangle represent the minimum and maximum values, while the peak vertex represents any event’s mode (the most common value).

According to respondents, it took one to four days for both parties to match the cargo with the right ship. Suppose a charterer needs a vessel of a specific type—crude oil carrier or product tanker of a particular size—sent to a specific port within a certain range of dates to load the nominated amount of cargo. In that case, the main challenge is that information is not publicly available:

Shipping is a 24-7 industry, but we are still dealing with humans who are hard to communicate with at times because of several factors. (Informant 23, technical superintendent)
Information sharing between shipping and supply chain organizations heavily relied on inefficient and error-prone manual processes (Li & Zhou, 2021). The charterer and shipowner mostly do not know each other. That is why brokers at each end withhold information (Li & Zhou, 2021). Hence, it takes more time for brokers to find the right match. As seen in this case, it takes both parties three to 10 days, with a median of seven days, to find a match, accept the vessel, and place it for the port authorities’ approval. This time-consuming process has a substantial commercial impact (Bavassano et al., 2020).

Similarly, the charterer and the consigner would pay additional inventory costs and absorb market price fluctuations. Once a match is found, negotiating the contract takes a more predictable time. Because negotiations follow a standard set of steps, the time is predictable.

Blockchain can transform the shipping industry (Loklindt et al., 2018). This trustworthy platform could reduce the communication chain so that both parties could save time and money through direct interaction. The charterer and the shipowner can register their information on the platform. With completed information, each party can make a query to search for a potential matching list. This process can help them search for a match instantly if there is a suitable one. In this case, they could bypass the broker. Blockchain-based identification systems would also stop frauds as the identities can be reliably connected to previous transactions done on blockchain to strengthen a user’s profile.

Based on this survey, the present process takes between half a day to four days with an average of two days. In the future, the blockchain platform could potentially find a match within seconds after receiving all required information through a database query. Two parties can take a few minutes to a few hours to review the details and confirm before entering the negotiation stage. Thus, this can reduce hours and days to minutes and hours. For example, the average hire rate in July 2021 for an average size (LR2, 80,000 to 160,000 DWT) product tanker was about $20,000–$25,000 per day. Assuming the ships do not have to be idle while waiting for the next hire, the potential time saved (two hours to four days) translates to a savings of $1,667 to $80,000 per transaction on the lower side of the range.

If the charterers and the shipowners engage in such platforms directly without involving brokers, they will save on the brokerage fees. The same example above, assuming a brokerage fee of 2.5% of hire, will save $500 per day per transaction. This can lead to enormous savings for the shipowner over time. Subsequently, the shipowner might reduce the hire rate to pass on these savings to the charterer to incentivize both parties.

Figure 3. Triangle Probability Density Function for the Number of Days It Takes for Charterers and Shipowners to Connect
In the past, several attempts were made to create an online marketplace. Opensea.pro is the most notable among them. Based on interviewees, the authors concluded that two main challenges remain to be addressed:

*We have seen some opportunities in having better communication tools and platforms, but we are not using them right now as we believe the technology needs to mature more. (Informant 23, technical superintendent)*

First, such a platform does not help bridge the trust gap between the shipowner and the charterer. Although the two parties will find each other quickly, it is improbable that they are ready to trust each other enough to enter into an agreement. For this reason, most of them still prefer going to a broker. The brokers connect the two parties and establish a chain of trust between them.

Second, there are very few participants on the platform. There are no significant incentives for early adopters to join, so the chances of finding a suitable match are low. Such a platform will need a network effort to succeed.

**Step 2: Negotiations Between Charterers and Shipowners**

Once a shipowner and charterer are connected, negotiations will begin. Two items involved in the negotiations are the hire rates and demurrage rates and the terms and conditions of carriages. The shipowner knows the distance for a voyage and calculates the expenses, before adding a profit margin. However, there is also a time factor associated with every voyage. At times, there is congestion at a port, or the rate of loading/discharging is too low, which means the ship will have to spend more time than what the shipowner has accounted for. To compensate for such unforeseen circumstances, shipowners use demurrage, the pre-agreed penalty paid per unit of time for any time spent on the voyage in addition to the agreed period of executing the port operations.

Based on common practice, 96 hours is assumed to be the allowance for berthing, unberthing, and cargo operations. Should a ship spend beyond that, the shipowner can be compensated by the charterer as demurrage. These are the issues that both parties will have to negotiate and agree on to confirm a hire. According to data, in the negotiations step, respondents were asked about the percentage of time they spent finding each other and the percentage of time they spent negotiating the terms and conditions based on three selections—shortest, most extended, and most common tender times. For example, selecting “1” means 10% of the time was spent on “Connecting” and 90% on “Negotiating.” Similarly, “4” means 40% of the time was spent on “Connecting” and 60% on Negotiating.”

The authors further verified the collected data with the interviews. Respondents suggested that the time taken in negotiating the terms and conditions and hire rates do not vary much across the deals. In contrast, the time spent finding a suitable match differs considerably.

The negotiation process is classified into two main categories: negotiations over the hire and demurrage and negotiations over the terms and conditions. Once both criteria are met, the charterer accepts the vessel and submits it for the port authorities’ approval. However, lack of price transparency, a complex and dynamic market, and ambiguous charter party terms and conditions lead to a very time-consuming process to complete the negotiation.

A possible solution is providing price transparency to reduce the time spent on price negotiations. Given the market practices, container shipping is more plausible than tanker markets. The tanker market spot rates are volatile, and the lanes are not always well-defined. It is common to mention a range of load/discharge ports in a charter party agreement instead of stating a single set of pots. The researchers suggest using the Baltic price index or the Worldscale 100 scale as a beginning point, and then the price is negotiated depending on the set of ports.

It may be challenging for any technology to resolve this issue. However, a blockchain-based consortium model is being tested in the container market. The New York Shipping Exchange (NYSHEX) is testing blockchain-based smart contract technology to address price volatility, unused
capacity, and a lack of transparency in the container shipping industry. The initiative takes a consortium approach involving various shippers and carriers. The shippers will view listings (with details such as price, lane, dates, etc.) from carriers with cargo space. Once the shipping accepts a listing’s terms, the agreement becomes binding and is recorded as a contract, and the cargo space is removed from
the exchange. The smart contract requires shippers and carriers to put up collateral worth a certain percentage of the contract amount. Any party that does not follow through forfeits the collateral.

Negotiations over other terms and conditions are time-consuming because both parties will manually check through any complex legal document:

Negotiating the terms and conditions of a charter party agreement is one of the most important jobs of all parties involved. Some standard terms and conditions are widely accepted and used. That makes negotiations easier to handle. Any rider clause needs special attention. (Informant 25, general manager)

Various online tools (such as chinsay.com) were developed using Natural Language Processing (NLP) algorithms to assist humans in speeding up this process. If used successfully, they will lead to savings regarding the number of hours spent in negotiations. Although there are no solid recommendations this stage, applying a blockchain-based exchange or an NLP algorithm remains a matter for further investigation.

The liquid bulk market is more global and unpredictable than the container market. An oil cargo destination is not well-known, even after loading in most cases, and it is common for the ships to sail out “for order” towards a range of ports instead of going to a particular port. Building a consortium of consigners, charterers, and carriers to establish an exchange for price transparency will be far more challenging.

**Step 3: Calculations and Payments**

This step is when the shiploads and discharges the cargo to meet the shipowner’s obligations in the charter party agreement:

The charter party agreement is central to everything that happens after that in moving goods through the oceans. (Informant 26, operations manager)

The shipowner will calculate based on the agreement and submit an invoice to get paid or compensated:

Signing of charter party agreement is a time-consuming exercise and involves some legal expertise on the part of everyone involved. Brokers usually don’t take any liability or obligatory position in the agreement. However, they are still expected to review it and ensure it covers everything discussed over the phone or emails. (Informant 13, founder and managing director)

To understand how much time is spent between the cargo discharge and the time a fund transfer is received (Question 7, Figure 5). This includes both hire and demurrage. The median values for the shortest, most extended, and most expected durations are 6, 88, and 20 days. The first data points (number of days <2) represent the hired cases, and demurrage was paid to the shop-owner within two days of discharge. These cases are likely examples of either the charter party (CP) having a Break Before Bulk clause and the voyage ending with no demurrage. If there are any discrepancies, a communication chain will delay the payments.

Then again, the data points on the upper side of the first plot (number of days >30) most likely indicate smaller owners and unprofessional charterers where payments are delayed despite all documentation being in order. Question 8 (refer to Figure 5), the data points on the bottom number of days <20, might indicate that the owner and the charterers are in a long-term relationship (pool arrangement) and the hire is being paid promptly. In contrast, the data points on the upper side (340–500
days) indicate delays in demurrage payment. These cases are mostly disputed, and arbitration might be in progress.

The three survey questions were combined and presented in the following triangle distribution chart (Figure 6).

The data shows that it might take 163 days to conclude the contracting process, excluding the days when the ship was engaged for cargo operations or sailing.

The process of calculating demurrage is relatively simple. The shipowner and the charterer often enter a dispute over the different interpretations of the CP, different timings, or missing supporting documents. All these will lead to delays in payment.

A blockchain-based, self-executing smart contract could solve all these problems using the blockchain’s consensus mechanism (Catalini, 2017; Letourneau & Whelan, 2017). The terms and conditions of the CP can be converted into a mathematical algorithm. Such an algorithm will take specific inputs, calculate based on information in a pre-defined, if-this-then-that formula, develop a non-disputable figure, and execute a fund transfer. As smart contracts can be pre-loaded with funds, this will guarantee that the shipowner receives funds if they meet the contract obligations. In such a scenario, this solves trust-related issues and removes the need for brokers.

With blockchain, all stakeholders can become participating nodes on a permissioned blockchain and give the smart contract inputs through a computer program (Letourneau & Whelan, 2017). If a
global positioning system (GPS) device is installed onboard, it will transmit its location to a smart contract to confirm the ship’s arrival in real time.

Since the data show that it takes 13 to 153 days to complete this stage, a self-executing smart contract can eliminate any chance of a dispute (Christidis et al., 2016). If the parties agree, the funds can be transferred within seconds as soon as the discharge is done. Even if some parties do not want to trade using cryptocurrency, the smart contract can be linked to their fiat bank accounts and execute
fund transfers within hours or days. This leads to considerable savings in the hours spent collecting information, calculating the figures, and managing a fund transfer.

**Scenario Data From July 2021 Ethereum Blockchain**

To convince conservative shipping industry practitioners (Bavassano et al., 2020), there is a need to estimate blockchain’s new costs and risks (Li & Zhou, 2021). This study uses scenario data from the Ethereum blockchain to analyze the potential cost and time savings.

Assuming $50 per hour cost of labor and taking on an average total of (including labor at both the charterer’s and the shipowner’s ends), 32 person-hours were spent (based on interviews) on collecting data, doing calculations, and carrying out the communication over email/phone calls. The cost is (number of person-hours spent) x (cost of labor per hour) = $1,600. On the other hand, the cost of executing a smart contract on the Ethereum blockchain involves:

**Step 1:** Calculating the units of gas required.
**Step 2:** Associating a gas price; see the current market condition and add a safety margin.
**Step 3:** Calling the contract and let it execute.

**Cost Calculations**

Figure 8 shows how the gas price is distributed and how confirmation time varies with the gas price.

Table 5 shows figures for the last 1,500 blocks on the Ethereum blockchain as of 6 July 2021 (YCHARTS, 2021a).

The total cost of running a smart contract in USD = (Units of Gas) x (Gas Price) x ($/ETH ratio at a given time):

- Units of gas can be from 6M gas to 0 gas.
- Gas price can be from 0.000005809 ETH to 0 (approximately).
- $/ETH ratio can be from $1,817 to $2,217, considering the ratio for two weeks preceding July 6, 2021 (YCHARTS, 2021a).

*Figure 8. Ethereum Transaction Count and Confirmation Time by GAS Price for Last 1,500 Blocks as of July 6, 2021 (YCHARTS, 2021a)*
Taking the median gas price for the last 1,500 blocks (58 gwei) and a complex contract of IM gas, the cost in USD at the $/ETH ratio on July 6, 2021 ($2,217) (YCHARTS, 2021a), the cost of executing a smart contract will be approximately = $133.

Next, the authors need to consider the cost of doing a fund transfer. At present, the transfers are done through banks. For international fund transfers, a network of banks helps move funds from one country to another. For this comparison, the authors neglect the taxes, and forex charges paid, if any, in the transaction.

Assuming remittance in the same currency, the transaction cost for an amount of $100,000 was approximately 0.1%.

If the cost of executing is the same process on smart contracts through cryptocurrencies. Transaction cost varies with time. Considering average transaction fees in the most recent blocks mined on July 6, 2021, the transaction fee for ETH was $7,982 or, in percentage, 0.008% (YCHARTS, 2021b).

So, a transaction of $100,000 will lead to a saving of $92 approximately. This is not a significant amount in terms of dollar value. However, saving time is a more substantial advantage of using a cryptocurrency-based fund transfer. In the current process, international fund transfers are done through a bank network, which takes several days to arrive. On the other hand, a fund transfer using cryptocurrency is done directly from the sender to the receiver. It takes only a few minutes on the blockchain.

The biggest challenge with the smart contract-based CP agreement is having a large amount of money locked into a contract for a period. Some voyage charters can take as long as two months to conclude. For so long, it will be challenging for any charterer to lock their liquid cash into a smart contract. The smart contract can be used as a trustful escrow account for solving disputes or managing deposits (Pu & Lam, 2021). The data show that any faster process that makes the payments might hurt the charterers and face resistance. Practically, it would be helpful for the charterers to be incentivized by the shipowner in some other way to convince them to adopt a smart contract-based solution. Offering a lower hire rate can be one such incentive that creates a win-win situation for both.

**DISCUSSION**

This paper set out to apply blockchain to resolve longstanding inefficiencies and challenges in the global shipping industry. Notably, this study contributes to the second stream of research that demonstrates the application of blockchain (Beck et al., 2016; Parra-Mayano, 2017) through empirical data. Given that the costs and risks that come with blockchain technology should be well-estimated and assessed (Li & Zhou, 2021), this study goes beyond the hyperbole in the media by providing a model to resolve end-to-end contract issues with trust and shipping efficiency (Figure 10).
The blockchain consortium solution builds on the end-to-end process through various applications. Figure 10 (right side) includes the shipowner, charterer, trader, port terminals, customs, banks, suppliers, and receivers. This simplified, disintermediated, efficient, and effective shipping ecosystem is superior to the current shipping industry condition as per Figure 9 (left side).

Detailed benefits of blockchain consortium and challenges are summarized in Figures 9 and 10.

Figure 9. Current Shipping Industry Supply Chain

Figure 10. Proposed Blockchain Consortium Shipping Industry Supply Chain
First, the blockchain consortium offers a possibility to optimize the administrative activities, by-passing delays linked to the documental flows (Loklindt et al., 2018; Bavassano et al., 2020) via the trustworthy platform to connect and match cargo with the ship without relying on trust between the transacting parties (Nakamoto, 2008; Bavassano et al., 2020). Ideally, it can solve issues such as schedule unreliability, port congestion, and no-show (Song, 2021). However, for the global shipping industry to properly benefit from blockchain, the culture within the shipping industry must improve (Song, 2021). For example, until now, brokers at each end still withhold information (Li & Zhou, 2021) or refuse to share information publicly. It will be challenging to apply blockchain to eliminate agents or intermediaries. Two main issues were identified. First, users find that blockchain does not help bridge the trust gap, so they still prefer to go to a broker. Although the platform speeds up the match, it is doubtful that they will readily trust each other enough to enter into an agreement. Second, there are very few participants in the platform as there are no significant incentives for early adopters to join the platform. Hence chances of finding a suitable match are low. More efforts are required to integrate different planning solutions from multiple perspectives to stimulate collaboration within the highly fragmented shipping supply chain (Song, 2021).

Second, the transparency of the blockchain consortium will improve the negotiation between charterers and shipowners using smart contracts supported by NLP algorithms that remove the intermediary when the predetermined conditions are met (Weston & French, 2021). In addition, the smart contract also improved security with fewer disputes because all documents are encrypted, hence offering a user-friendly environment (Krishna, 2019). However, there is still some adjustment required. For example, the destination of an oil cargo is usually not well-known as it is common for the ships to sail out “for orders” towards a range of ports instead of going to a specific port. Therefore building a consortium for the liquid bulk market to establish an exchange for price transparency will be far more challenging. Hence, business process issues within the shipping industry are worth further investigation (Tirschwell, 2017).

Finally, the smart contract could resolve longstanding disputes in calculations by using an algorithm to compute an accurate and non-disputable figure and automate payment via cryptocurrency or direct banking transactions. Furthermore, it can impose financial penalties if certain objective conditions are not satisfied (Levi et al., 2018).

The calculations in Section 4.4 show considerable time and cost-saving opportunities using a public blockchain such as Ethereum. However, the biggest challenge with a smart contract-based CP agreement is to lock in a large amount of liquid cash into a smart contract. The smart contract can still be implemented without locking in the money, but that will serve only as a time-saving tool and not be able to fill in the trust gap between the shipowner and the charterer. Further, any process that speeds up the payment will hurt the charterers and face resistance. Therefore, shipowners must find ways to incentivize charterers to adopt smart contract-based solutions should they like to benefit from using them.

Despite these challenges, the blockchain consortium revolutionizes end-to-end document management solutions by digitalizing paperwork. However, cultural issues such as trust, the potential to eliminate intermediaries (Li & Zhou, 2021; Bavassano et al., 2020), and fragmented supply chain issues (Song, 2021) would require more incentives to attract participants to commit to Blockchain for more efficient and effective global shipping trade flows (Li & Zhou, 2021).

CONCLUSION

This research fills the gap of how blockchain can improve the shipping process with better efficiency and cost. The empirical findings offer potential cost and time savings in maritime shipping, so practitioners should consider blockchain as the solution for improving global trade flows. Blockchain provides better transparency and traceability that is currently needed globally (Masudin et al., 2021),
given that the coordination and cooperation within the global supply chain tend to be broader and more comprehensive (Hung et al., 2022).

Practical Implications

Since only a few studies have focused on the blockchain in the shipping industry (Tan et al., 2018), the empirical findings set a foundation to extend the knowledge of shipping literature to revolutionize and digitalize shipping operations and processes. First, this research advances the need to optimize and digitalize the shipping literature (Loklindt et al., 2018; Bavassano et al., 2020), and this confirms the importance of changing the shipping industry culture and the need to stimulate collaboration within the highly fragmented shipping supply chain (Song, 2021).

Second, this paper empirically contributes to the second stream of blockchain research from the perspective of blockchain consortium applications (Beck et al., 2016; Parra-Moyano & Ross, 2017). This study shows blockchain applications in the shipping industry with a proposed blockchain consortium model. The study also further extends the literature with blockchain application challenges, such as its scalability and volatility issues that will remain continuous challenges in the shipping industry.

Third, this study adds to the need to understand the greater efficiency of blockchain literature (Tan et al., 2018) with empirical data to discuss the blockchain technology’s estimated cost and potential risks, as pointed out by Li and Zhou (2021). For example, a blockchain consortium can address longstanding inefficiencies and challenges within the shipping industry. It can also digitalize paperwork with end-to-end document management solutions, data accuracy, and improved security and transparency (Krishna, 2019).

Finally, this study adds to the smart contract literature (Negara et al., 2021). The findings suggest that disintermediation with smart contracts could simplify and speed up shipping supply chain processes while saving costs. Still, business processes, scalability, and volatility challenges need to be addressed to fully benefit from the smart contract application in the shipping industry.

Managerial Implications

Improving stakeholder relationships within the shipping supply chain (Song, 2021) is crucial for developing comprehensive practices for a shipping blockchain consortium to achieve win-win benefits. Since conservativism has always been a challenging issue in this industry (Bavassano et al., 2020), this study offers clear managerial implications by applying Ethereum blockchain data as of July 2021. Now, shipping industry practitioners must change their behaviors (Song, 2021) and be open and willing to overcome conservativism (Bavassano et al., 2020).

Education is needed for shipping industry practitioners, primarily technological understanding, as people play a vital role in revolutionizing the shipping industry. Practitioners must be willing to harmonize new shipping processes, standards, and policies (Bavassano et al., 2020). A proper appreciation of blockchain will reduce the technology resistance issues. Furthermore, attractive incentives will attract participants to commit to blockchain for more efficient and effective global shipping trade flows (Li & Zhou, 2021).

Limitations and Future Research

The findings could be extended by applying the proposed solution in practice. More industry participation is needed to provide richer insights into understanding the shipping industry supply chain challenges and barriers to successful blockchain-based information exchanges (Jovic et al., 2020). Despite the limitation of the survey sample size, the authors are convinced that this research is valuable since they obtained 20 in-depth interviews to understand how blockchain technology can be applied in the logistics and supply chain (Kummer et al., 2020).

This research raised several issues associated with blockchain consortium applications in the shipping industry. Despite the rising interests and potential benefits, most of the existing blockchain
consortium has not been able to scale (Chirstory et al., 2019). There are no significant incentives for early adopters to join the blockchain consortium. Furthermore, topics such as new standards, processes, regulations, and policies are needed to allow all parties within the ecosystem to compete on a more level playing field. The proposed self-execution smart contract can also be further researched and examined for its applicability and sustainability in the shipping industry. Future research can extend based on these findings as they are critical to the evolution of blockchain consortiums in the shipping industry to improve global trading.
REFERENCES

Ada, E., Sagnak, M., Kazancoglu, Y., Luthar, S., & Kumar, A. (2021). A framework for evaluating information transparency in supply chains. *Journal of Global Information Management, 29*(6), 1–22. doi:10.4018/JGIM.20211101.oa45

Allen, D. W. E., Berg, C., Davidson, S., Novak, M., & Potts, J. (2019). International policy coordination for blockchain supply chains. *Asia & the Pacific Policy Studies, 6*(3), 367–380. doi:10.1002/app5.281

Bavassano, G., Ferrari, C., & Tei, A. (2020). Blockchain: How shipping industry is dealing with the ultimate technological leap. *Research in Transportation Business & Management, 34*, 34. doi:10.1016/j. rtbm.2020.100428

Beck, R., Stenum Czepluch, J., Lollike, N., & Malone, S. (2016). *Blockchain – The Gateway to Trust-Free Cryptographic Transactions*. Paper presented at the European Conference on Information Systems, Istanbul, Turkey.

Behrendt, S., Richter, A., & Trier, M. (2014). Mixed methods analysis of enterprise social networks. *Computer Networks, 75*, 560–577. doi:10.1016/j.comnet.2014.08.025

Berdik, D., Otoum, S., Schmidt, N., Porter, D., & Jarah, Y. (2021). A Survey on Blockchain for Information Systems Management and Security. *Information Processing & Management, 58*(1), 58. doi:10.1016/j.ipm.2020.102397

Bloomberg. (2018). *Blockchain is about to revolutionize the shipping industry*. Retrieved from: https://www.bloomberg.com/professional/blog/blockchain-revolutionize-shipping-industry/

Buthelezi, B. E., Ndayizigamiye, P., Twinomurinzi, H., & Dube, S. (2022). A systematic review of the adoption of blockchain for supply chain processes. *Journal of Global Information Management, 30*(8), 1–32. doi:10.4018/JGIM.297625

Cargo Shipping International. (2020). *The scope of automation in the shipping industry*. Retrieved from https://www.cargoshippinginternational.com/the-scope-of-automation-in-the-shipping-industry/

Casino, F., Dasaklis, T. K., & Patsakis, C. (2019). A systematic literature review of blockchain-based applications: Current status, classification and open issues. *Telematics and Informatics, 36*, 55–81. doi:10.1016/j.tele.2018.11.006

Catalini, C. (2017). *How Blockchain applications will move beyond Finance*. *Harvard Business Review*. Retrieved from https://hbr.org/2017/03/how-blockchain-applications-will-move-beyond-finance

Catalini, C., & Gans, J. S. (2016). *Some simple Economics of the Blockchain*. NBER Working Papers 22952. National Bureau of Economic Research, Inc. Retrieved from https://ideas.repec.org/p/nbr/nberwo/22952.html

Christidis, K., & Devetsikiotis, M. (2016). Blockchain and smart contracts for the Internet of things. *IEEE Access: Practical Innovations, Open Solutions, 4*, 4. doi:10.1109/ACCESS.2016.2566339

Christory, C. D., Benhamed, R., Xu, S., & Obadia, J. (2019). Success factors for a blockchain consortium. Retrieved from https://static1.squarespace.com/static/59aae5e9a803bb10bedeb03e/t/5f4810389b2de246e60 6f913/1598558268071/Blockchain+Consortium+Success+Factors_Final+Draft+v2.pdf

Conoscenti, M., Vetrò, A., & Martin, J. C. D. (2016). Blockchain for the Internet of Things: A systematic literature review. *Proceeding of IEEE/ACS 13th International Conference of Computer Systems and Applications (AICCSA)*. doi:10.1109/AICCSA.2016.7945805

Consensys. (2020). *Blockchain in Retail Fashion & Luxury*. https://consensys.net/blockchain-use-cases/retail-fashion-and-luxury/

Dresher, D. (2017). *Blockchain basis: A non-technical introduction in 25 Steps* (1st ed.). Apress. doi:10.1007/978-1-4842-2604-9

Frizzo-Barker, J., Chow-White, P. A., Adams, P. R., Mentanko, J., Ha, D., & Green, S. (2020). Blockchain as a disruptive technology for business: A systematic review. *International Journal of Information Management, 51*, 51. doi:10.1016/j.ijinfomgt.2019.10.014
Gagliordi, N. (2018). *Walmart implements IBM's blockchain for food traceability*. Retrieved from https://www.zdnet.com/article/walmart-implements-ibms-blockchain-for-food-traceability/

Gausdal, A. H., Czachorowski, K. V., & Sølesvik, M. Z. (2018). Applying blockchain technology: Evidence from Norwegian companies. *Sustainability, 10*(6), 1985. doi:10.3390/su10061985

Gerring, J. (2008). Case selection for case-study analysis: Qualitative and quantitative techniques. In *The oxford handbook of political methodology*. Oxford University Press. doi:10.1093/oxfordhb/9780199286546.003.0028

Gervais, A., Karame, G., Capkun, V., & Capkun, S. (2014). Is Bitcoin a decentralized currency? *IEEE Security and Privacy Magazine, 12*(3), 54–60. doi:10.1109/MSP.2014.49

Gervais, A., Karame, G. O., Wüst, K., Glykantzis, V., Ritzdorf, H., & Capkun, S. (2016). On the Security and Performance of Proof of Work Blockchains. *Proceedings of ACM SIGSAC Conference on Computer and Communications Security*. doi:10.1145/2976749.2978341

Glaser, F. (2017). Pervasive Decentralization of Digital Infrastructures: A Framework for Blockchain enabled System and Use Case Analysis. *Proceeding of Hawaii International Conference on System Sciences*. doi:10.24251/HICSS.2017.186

Gomber, P. (2016). Financial IS, Underlying Technologies, and the Fintech Revolution. *Journal of Management Information Systems*.

Gomber, P., Kauffman, R. J., & Weber, B. W. (2016). Financial IS, Underlying Technologies, And The FinTech Revolution. *Journal of Management Information Systems*.

Hafizon, M. I., Wicaksono, A., & Farizan, F. N. (2019). E-Toll Laut: Blockchain port as the key for realizing Indonesia's maritime fulcrum. *Proceeding of ACM International conference*, 36–45. doi:10.1145/3326365.3326371

Hughes, L., Dwivedi, Y. K., Misra, S. K., Rana, N. P., Raghavan, V., & Akella, V. (2019). Blockchain research, practice and policy: Applications, benefits, limitations, emerging research themes, and research agenda. *International Journal of Information Management, 49*, 114–129. doi:10.1016/j.ijinfomgt.2019.02.005

Hung, W.-H., Chang, F.-K., Lin, C.-P., & Cheng, I.-C. (2022). A self-assessment framework for global supply chain operations: Case study of a machine tool manufacturer. *Journal of Global Information Management, 30*(1), 1–25.

Iansiti, M., & Lakhani, K. R. (2017). The Truth About Blockchain. *Harvard Business Review*. Retrieved from https://hbr.org/2017/01/the-truth-about-blockchain

IBM. (2017). *Three ways blockchain Explorers chart a new direction*. Retrieved from https://www-935.ibm.com/services/studies/csuite/pdf/GBE03835USEN-00.pdf

International Chamber of Shipping. (2021). *Shipping and World Trade: World Seaborne Trade*. Retrieved from https://www.ics-shipping.org/shipping-fact/shipping-and-world-trade-world-seaborne-trade/

Jain, D., Dash, M. K., Kumar, A., & Luthra, S. (2021). How is blockchain used in marketing: A review and research agenda. *International Journal of Information Management Data Insights, 1*(2), 100044. doi:10.1016/j. jjimei.2021.100044

Jiang, J. H. (2017). *How much does trust cost: Analysis of the consensus mechanism of distributed ledger technology and use-cases in securitization*. Massachusetts Institute of Technology. Retrieved from https://dspace.mit.edu/handle/1721.1/111454

Jovic, M., Tijan, E., Žgaljić, D., & Aksentijević, S. (2020). Improving maritime transport sustainability using blockchain-based information exchange. *Sustainability, 12*(21), 8866. Advance online publication. doi:10.3390/su12218866

Kapnissis, G., Leligou, E-E., & Vaggelas, G. (2020). *Blockchain challenges in the maritime industry: An empirical investigation of the willingness and the main drivers of adoption by the Hellenic Shipping industry*. Academic Press.

Kar, A. K., & Navin, L. (2021). Diffusion of blockchain in insurance industry: An analysis through the review of academic and trade literature. *Telematics and Informatics, 58*, 101532. doi:10.1016/j.tele.2020.101532
Krishna, V. (2019). How can Blockchain and smart contracts help the shipping industry. Retrieved from https://blog.ipleaders.in/blockchain-contracts-shipping-industry/

Kumari, K., & Saini, K. (2020). Data handling & drug traceability: Blockchain meets healthcare to combat counterfeit drugs. International Journal of Scientific and Technology Research, 9(3), 728–731.

Kummer, S., Herold, D. M., Dobrovnik, M., Mikl, J., & Schäfer, N. (2020). A Systematic Review of Blockchain Literature in Logistics and Supply Chain Management: Identifying Research Questions and Future Directions. Future Internet, 12(3), 60. doi:10.3390/fi12030060

Lacity, M., & Hoek, R. V. (2021). What we’ve learned so far about blockchain for business. MIT Sloan Management Review. Retrieved from https://sloanreview.mit.edu/article/what-weve-learned-so-far-about-blockchain-for-business/

Lacity, M. C. (2018). Addressing key challenges to making enterprise blockchain applications a reality. MIS Quarterly Executive, 17(3), 201–222.

Letourneau, K.B. & Whelan, S.T. (2017). Blockchain: Staying Ahead of Tomorrow. The Journal of Equipment Leasing & Finance Foundation.

Levi, S. D., & Lipton, A. B. (2018). An Introduction to smart contracts and their potential and inherent limitations. Retrieved from https://corpgov.law.harvard.edu/2018/05/26/an-introduction-to-smart-contracts-and-their-potential-and-inherent-limitations/

Li, L., & Zhou, H. (2021). A survey of blockchain with applications in maritime and shipping industry. Information Systems and e-Business Management, 19(3), 789–807. doi:10.1007/s10257-020-00480-6

Lincoln, Y., & Guba, E. (1985). Naturalistic Inquiry. Sage. doi:10.1016/0147-1767(85)90062-8

Loklindt, C., Moeller, M.-P., & Kinra, A. (2018). How blockchain could be implemented for exchanging documentation in the shipping industry. doi:10.1007/978-3-319-74225-0_27

Masudin, I., Ramadhani, A., Restuputri, D. P., & Amallynda, I. (2021). The effect of traceability system and managerial initiative on Indonesia Food Cold chain performance: A Covid-19 Pandemic Perspective. Global Journal of Flexible Systems Management, 22(4), 331–356. doi:10.1007/s40171-021-00281-x

Nakamoto, S. (2008). Bitcoin: A Peer-to-Peer Electronic Cash System. Retrieved from https://bitcoin.org/bitcoin.pdf

Negara, E. S., Hidayanto, A. Z., Andryani, R., & Syaputra, R. (2021). Survey of smart contract framework and its application. Information (Basel), 12(7), 257–267. doi:10.3390/info12070257

Palinkas, L. A., Horwitz, S. M., Green, C. A., Wisdom, J. P., Duan, N., & Hoagwood, K. (2015). Purposeful sampling for qualitative data collection and analysis in mixed method implementation research. Administration and Policy in Mental Health, 42(5), 533–544. doi:10.1007/s10488-013-0528-y PMID:24193818

Parra-Moyano, J., & Ross, O. (2017). KYC Optimization Using Distributed Ledger Technology. Business & Information Systems Engineering, 59(6), 411–423. doi:10.1007/s12599-017-0504-2

Pee, L. G., Pan, S. L., Li, M. W., & Jia, S. L. (2020). Social informatics of information value Co-creation: A case study of Xiaomi’s online user community. Journal of the Association for Information Science and Technology, 71(4), 409–422. doi:10.1002/asi.24252

Pirrong, S. C. (1993). Manipulation of the Commodity Futures Market Delivery Process. The University of Chicago Press. doi:10.1086/296608

Pu, S., & Lam, J. S. L. (2021). Blockchain adoptions in the maritime industry: A conceptual framework. Maritime Policy & Management, 48(6), 777–794. doi:10.1080/03088839.2020.1825855

Risius, M., & Spohrer, K. (2017). A Blockchain Research Framework: What We (don’t) Know, Where We Go from Here, and How We Will Get There. Business & Information Systems Engineering, 56(6), 385–409. doi:10.1007/s12599-017-0506-0

Schweizer, A., Schlatt, V., Urbach, N., & Fridgen, G. (2017). Unchaining Social Businesses – Blockchain as the Basic Technology of a Crowdlending Platform. Proceeding of the International Conference on Information Systems.

Shah, S. K., & Corley, K. G. (2006). Building better theory by bridging the quantitative-qualitative divide. Journal of Management Studies, 43(8), 1821–1835. doi:10.1111/j.1467-6486.2006.00662.x
Shou, Y., Zhao, X., & Xu, D. D. (2021). Matching traceability and supply chain coordination: Achieving operational innovation for superior performance. *Transportation Research Part E, Logistics and Transportation Review, 145*, 102181. doi:10.1016/j.tre.2020.102181

Song, D. (2021). A literature review, container shipping supply chain: Planning problems and research opportunities. *Logistics, 5*(2).

Stiglitz, J. E. (2002). *Globalization And Its Discontents*. W. W Norton & Company.

Stopford, M. (2009). *Maritime Economics* (3rd ed.). Routledge.

Sultana, J., Teoh, S. Y., & Karanasios, S. (2022). The impact of blockchain on supply chains: A systematic review. *AJIS. Australasian Journal of Information Systems, 26*, 26. doi:10.3127/ajis.v26i0.3755

Swanson, T. (2015). *Consensus-as-a-service: a brief report on the emergence of permissioned, distributed ledger systems*. 10.1017/CBO9781107415324.004

Szabo, N. (1997). *The idea of smart contracts*. Retrieved from https://bit.ly/2JJQ750

Tama, B. A., Kweka, B. J., Park, Y., & Rhee, K.-H. (2017). A critical review of blockchain and its current applications. *Proceeding of International Conference on Electrical Engineering and Computer Science (ICECOS)*. doi:10.1109/ICECOS.2017.8167115

Tan, A. W. K., Zhao, Y., & Halliday, T. (2018). A blockchain model for less container load operations in China. *International Journal of Information Systems and Supply Chain Management, 11*(2), 39–53. doi:10.4018/IIJSSCM.2018040103

Tandon, C., Revankar, S., & Parihar, S. S. (2021). How can we predict the impact of the social media messages on the value of cryptocurrencies? Insights from big data analytics. *International Journal of Information Management Data Insights, 1*(2), 100035. doi:10.1016/j.jiimei.2021.100035

Teddle, C., & Tashakkori, A. (2009). *Foundations of Mixed Methods Research*. Sage Publications.

Tirschwell, P. (2017). “No Shows” Key to service contract evolution. *The Journal of Commerce Online*. Retrieved from https://www.joc.com/maritime-news/container-lines/predictability-cargo-flows-vital-cost-savings_20170508.html

Transparency Market Research. (2020). *Liquid and Bulk Transportation Vessels Market*. Retrieved from: https://www.transparencymarketresearch.com/liquid-bulk-transportation-vessels-market.html

United Nations Conference on Trade and Development. (2021). *COVID-19 and maritime transport: impact and responses*. Retrieved from https://unctad.org/system/files/official-document/dtltlbinf2020d1_en.pdf

Venkatesh, , Brown, S. A., & Bala, H. (2013). Bridging the qualitative-quantitative divide: Guidelines for conducting mixed methods research in information systems. *Management Information Systems Quarterly, 37*(1), 21–54. doi:10.25300/MISQ/2013/37.1.02

Weston, M., & French, M. (2021). Can blockchain technology revolutionize the shipping industry? Retrieved from https://www.hilldickinson.com/insights/articles/can-blockchain-technology-revolutionise-shipping-industry

Wust, K., & Gervais, A. (2018, June). Do you need a blockchain. *2018 Crypto Valley Conference on Blockchain Technology*, Zug, Switzerland.

YCHARTS. (2021a). *Ethereum Price*. Retrieved from https://ycharts.com/indicators/ethereum_price

YCHARTS. (2021b). Retrieved from https://ycharts.com/indicators/ethereum_average_transaction_fee

Yli-Huumo, J., Choi, D. K. S., Park, S., & Smolander, K. (2016). Where Is Current Research on Blockchain Technology? A Systematic Review. *PLoS One, 11*(10), 1–27. doi:10.1371/journal.pone.0163477 PMID:27695049

Yong, B., Shen, J., Liu, X., Li, F., Chen, H., & Zhou, Q. (2020). An intelligent blockchain-based system for safe vaccine supply and supervision. *International Journal of Information Management, 52*, 52. doi:10.1016/j.ijinfomgt.2019.10.009

Zhao, J. L., Fan, S., & Yan, J. (2016). Overview of business innovations and research opportunities in blockchain and introduction to the special issue. *Financial Innovation, 2*(1), 28. doi:10.1186/s40854-016-0049-2
APPENDIX

Appendix 1a. Survey questions

Signing a Charter Party Agreement
This survey seeks to quantify the time taken in signing a charter party agreement in the spot oil-tanker market (voyage charters). On an average, it takes 5 minutes to fill this form. Your response will be kept strictly confidential and will be used for academic purpose only. If you are interested in knowing the findings of this research, please drop your email address. Please read the description below before you start answering the questions.

The process of signing a Charter Party (CP) is assumed to begin with either a ship-owner or a charterer coming out with the tonnage details in the market and end with the transfer of funds as a consideration for the CP.

In the first part of the survey, we look at the period of time from the beginning till the time the vessel is put on-sub. Please consider all the CPs that you have signed or have helped getting signed over the last 2-3 years and answer the below questions:

*Required

1. Name
   (Optional)

2. Email address
   (Please enter if you are willing to take follow-up questions, if any, based on your response OR if you are interested in knowing the findings of this research. Else, leave blank.)

3. I am a *
   Mark only one oval.
   - Charterer/trader
   - Ship-owner/operator/manager
   - Broker
   - Other: ___________________________

Part I
Appendix 1b. Survey questions

The next 3 questions are about the time it takes to find a suitable cargo/vessel, negotiate the hire/terms & conditions and get the vessel on-sub.

4. 1. What is the shortest (or fastest) this has taken (in days)? *

5. 2. What is the longest (or slowest) this has taken (in days)? *

6. 3. What is the most common duration (in days)? *

Now, in the next 3 questions, we want to ask about the time required for: Connecting (finding each other) and Negotiating (hired/demarriage/T&C, etc.) the final terms.

7. 4. For very FAST tender times, what percent of the total time was spent on Connecting versus Negotiating? *
   
   Mark only one oval.

   |   |   |   |   |   |   |   |   |   |   |
   |---|---|---|---|---|---|---|---|---|---|
   | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
   | 'Connect' | 'Negotiate' | |

8. 5. For very SLOW tender times, what percent of the total time was spent on Connecting versus Negotiating? *

   Mark only one oval.

   |   |   |   |   |   |   |   |   |   |   |
   |---|---|---|---|---|---|---|---|---|---|
   | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
   | 'Connecting' | 'Negotiating' | |

9. 6. For the MOST COMMON tender times, what percent of the total time was spent on Connecting versus Negotiating? *

   Mark only one oval.

   |   |   |   |   |   |   |   |   |   |   |
   |---|---|---|---|---|---|---|---|---|---|
   | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
   | 'Connecting' | 'Negotiating' | |

In this part we seek to collect information on how much time is spent between discharge of the cargo and the time a fund transfer is received in the accounts of the receiver. This includes both hire and demarriage. (It has been noted that it takes several months in some cases to receive the demarriage, we intend to capture that information.)

Part II

Please consider all the CPs that you have signed or have helped getting signed over the last 2-3 years and answer the下列 questions.
Appendix 1c. Survey questions

10. 7. What is the shortest (or fastest) this has taken (in days)? *


11. 8. What is the longest (or slowest) this has taken (in days)? *


12. 9. What is the most common duration (in days)? *


13. 10. Any comments/suggestions
    (Optional)

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Appendix 2. Sample interview questions for brokers, shipowners and charterers

1. You were asked to select one role for the survey out of a charterer (trader), a shipowner (operator/manager), or a broker. You selected x, which being your most recent role. In the past, which other roles out of these three have you played in your career?
2. (if you have played more than one of these roles in the past) which of these roles, did you find the most challenging?
   - What were the challenges you had to deal with?
   - Which one is a more rewarding option? Why?
3. As a charterer, shipowner/broker, do you have a strong preference to engage in more time charters vs voyage charters? Why?
4. Who do you think the current market conditions favor - the ship-owners or the charterers?
5. What are your predictions about this trend?
6. Do you believe that this market condition has an impact on the time it takes to execute the charter party agreement?
7. What are some of the tools you use to manage the communication related to signing a charter party agreement?
8. Do you feel there is a need to create better tools to improve this communication?
9. What is the size of the team at your end that handles the communications and decisions related to the signing of a charter party agreement?
10. Do you think the size of the team plays a significant role or acts as a bottleneck for the time it takes to execute a charter party agreement?
11. What are the tools you use to handle the financial transactions related to the charter party agreement?
12. Do you see an opportunity to speed up the end-to-end charter party agreement process by using better financial tools?

Sample questions for shipowners and charterers:

1. As a charterer, ship-owner, do you see handling the bill of lading as a challenge when dealing with the ship-owners/charterers on voyage charters?
2. In your survey response, you have mentioned that the shortest/longest it took for a certain deal was x number of days.
3. Can you please explain what happened there and if there was any special reason for this extreme behavior?

Sample questions for brokers:

1. As a broker, what steps do you take, if any, to speed up the processes involved in signing and executing a charter party agreement?
2. What changes in the process, in your opinion, can help improve this process?
3. Do you foresee any challenges in improving this process?

Appendix 3. Sample of variables used from literature

| Example | Literature |
|---------|------------|
| Maritime shipping failed to meet the need for on-time, faster deliveries and traceability and transparency of their shipments (Shou et al., 2021). | To understanding the inefficiencies in the shipping industry, interview questions as the following were designed. For example: |
| This time-consuming process also has a substantial commercial impact (Cassavoias et al., 2020). | Time taken to find a suitable cargo vessel, negotiate the hire terms & conditions and get the vessel on-sub. (Survey questions 4 to 9): |
| Finding the right match using multiple communication platforms and brokers and intermediaries further complicates and delays the process of using brokers and intermediaries (Li and Zhou, 2021). | 4. What is the shortest (or fastest) this has taken (in days)? |
| | 5. What is the longest (or slowest) this has taken (in days)? |
| | 6. What is the most common duration (in days)? |

| Time required for Connecting (finding each other) and Negotiating (hire/demurrage/T&D etc) the final terms. (For every FAST tender time, what percent of the total time was spent on Connecting vs. Negotiating)? |
| Time for very SLOW tender times, what percent of the total time was spent on Connecting vs. Negotiating? |
| For the MOST COMMON tender times, what percent of the total time was spent on Connecting vs Negotiating? |

| interview question 6: Do you feel there is a need to create better tools to improve this communication? | 3. Do you foresee any challenges in improving this process? |
Appendix 4. Core themes and quotations

- Maritime shipping failed to meet the need for on-time, faster deliveries and traceability and transparency of their shipments (Shou et al., 2021).
  
- Particularly, the bulk ocean freight markets suffer from temporal specificities because of the time and space (location) factors. This leads to haggling between shipper and carrier over the hire rates (Brown, 1998).

| Core theme                  | Sub-theme       | Quotation                                                                 |
|-----------------------------|-----------------|---------------------------------------------------------------------------|
| Market condition and impact | Time taken/speed| “The time taken to respond to queries has a fixed as well as a variable component. The variable part is driven by the market conditions. A ship-owner who has a ship already on hire response with a faster speed than one which has multiple options to choose from. Brokers who have a good relationship with them understand this better and act accordingly.” Informant#5, Broker |

Interview question 6:
Do you believe that this market condition has an impact on the time it takes to execute the charter party agreement?

Interview question for broker:
As a broker, what steps do you take, if any, to speed up the processes involved in signing and executing a charter party agreement?

Appendix 4a.

| Communication and decision | Better communication tools | Time zones                                                                 |
|----------------------------|-----------------------------|---------------------------------------------------------------------------|
| “Shipping is a 24-7 industry, but we are still dealing with humans who are hard to communicate with at times because of several factors.” Informant#23, Technical Superintendent |
| “Having the right communication channels leads to better and faster decisions. In the era of the internet, it is still helpful to meet people in person frequently.” Informant#2, Broker |
| “Market conditions do dictate the speed at which different parties respond but over a long period of time, as the markets go in cycles, these factors are balanced out.” Informant#21, Managing Director |
| “Covid pandemic has made communication and maintaining relationships challenging. Better communication tools are needed but we are still using the same old tools.” Informant#27, Director |
| “We have seen some opportunities in having better communication tools. Platforms but we are not using them right now as we believe the technology needs to mature more.” Informant#23, Technical Superintendent |
| The difference in time zones sometimes makes communication challenging. By the time Hong Kong opens, most of Europe is already preparing to go to bed. Negotiations take longer than usual although people do work round the clock in most cases.” Informant#3, Manager, Tanker Chartering & Gas Projects |
### Appendix 4b.

| Charter party agreement | Trust |
|-------------------------|-------|
| "The charter party agreement is central to everything that happens thereafter in moving goods through the oceans." Data used: Informant#26, Operations Manager | "Signing of charter party agreement is just the beginning. It means nothing if the parties don't already trust each other. Nobody wants to go to a court with the agreement to settle claims. Trust is imperative." Informant#12, General Manager |
| "Signing of charter party agreement is a time-consuming exercise and involves some legal expertise on the part of everyone involved. Brokers usually don't take any liability or obligatory position in the agreement but are still expected to review it and make sure it covers everything that has been discussed over phone or email." Data used: Informant#18, Founder and Managing Director | "Charter party agreement is more of an outcome of trust that the brokers build than a tool to establish trust." Informant#7, CEO |
| **Negotiation** | Negotiating the terms and conditions of a charter party agreement is one of the most important jobs of all parties involved. There are standard terms and conditions that are widely accepted and used. That makes negotiations easier to handle. Any rider clause needs special attention." Data used: Informant#25, General Manager |

### Appendix 4c.

| Financial transactions | Demurrage |
|------------------------|-----------|
| "The money transactions are closely tied to the operations of the vessel. The owners want to make sure their vessel is constantly occupied and that they don't waste any time waiting for instructions from the charterers and the charterers want to make sure there have not been any delays because of unavailability of the ship for reasons such as a machinery failure. This requires a lot of reconciliation of documents to establish truth before a transaction is initiated." Informant#6, Tanker Chartering Manager | "Demurrage takes more time than receiving freight." Informant#22, Technical Superintendent |
| **Transaction delays** | Freight gets settled within a week after discharge, but counterparties usually took a longer time to verify the claims and they also target the claims deadline as agreed in OP to settle. Anyone would be happy to hold someone else money without interest and that's what the Charterer does. Informant#22, Technical Superintendent |
Harshvardhan has over 14 years of experience in maritime shipping, logistics, and supply chain management. After sailing world-wide on ocean-going oil tankers as a merchant marine officer, he worked as a superintendent providing commercial and technical management services to a fleet of oil tankers. In his current role, he works as a supply chain research and development specialist for a fortune 100 grocery retailer and focuses on application of emerging technologies on improving supply chains. He holds a B.Sc. Nautical Science degree from the University of Mumbai and an M.Eng. in Supply Chain Management from Massachusetts Institute of Technology (MIT).

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