“The Benefits of utilizing Blockchain and Big Data in the maritime industry.”

This paper is conducted by

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Abstract

Digitalization has been recognized as an ongoing process occurring in the maritime sector due to innovating technologies disrupting and changing how business is conducted. This paper aims to develop a comprehensive theoretical overview and practical approach to Blockchain and big data, analyzing the benefits provided by their application in the maritime sector. There are many theoretical applications concerning both innovating technologies that are researched in great detail. Since Blockchain is still in its early stages, it is approached with the perspective of how it can aid the daily challenges of shipping, such as the heavy paper-based documentation. Part of the research is conducted on adopting both technologies in combination, which provides benefits such as efficiency, transparency, safety, and cost reduction. In order to understand the full complexity, the challenges and the possible barriers are explored, such as data issues, governance, and technology integration. Data is drawn from a bibliography overview of theoretical and practical cases analyzing the topic and interviews from maritime professionals with a deep understanding of both technologies, providing input and feedback on the possible application of such technologies and evaluating future opportunities. Conjointly with the interview findings, future opportunities are examined, and many examples are provided, including possible developments in integrating both technologies in the maritime industry.

Keywords: Big Data, Blockchain, Digitalization, Maritime Technology, Maritime Economics.

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1. Introduction

The rapid development of technology in recent years has contributed significantly to the optimization of practices used by various sectors of the economy in order to maximize profits and minimize costs, while at the same time seeking a competitive advantage. Even though shipping is considered a traditional industry primarily, in recent years, there has been an effort to modernize operations; with a new goal to adopt innovative technologies and evolve from their traditional ways, a radical revolution can take place in the industry. The referred technologies are Big Data and Blockchain; despite their theoretical research there has been, the industry has not yet given the related interest, which raises many concerns. Undoubtedly there is a need for a total overview of technical components of each technology, multiple applications, and barriers, which is the purpose of this paper. Furthermore, qualitative research took place, providing the opinion of maritime professionals and an understanding of the barriers to integration.

2. The importance of Big Data and its applications in the maritime industry.

Big data is a term that describes the enormous volume of information in structured (numeric, easily stored, and formatted), semi-structured, and unstructured (less quantifiable) forms collected by different sources. (Address at Trinity College, Washington)
It is characteristically described with the 5 V's:

- Volume: The vast amount of data collected every second, the enormous size is measured in Petabyte (PB) and Exabyte (EB).
- Velocity: The high speed at which data is created.
- Variety: The data heterogeneity is created by the large capacity of information.
- Veracity: Due to the large amount of data, there must be accuracy and reliability.

- Value: The most critical factor is to generate value after the procession of big data, thus creating a return on the investment of the cost of resources and other expenditures.

The importance lies in the profound new business capabilities that have emerged from analyzing data, acknowledging patterns and opportunities that can influence decision making and business strategy. Lately, there have been many opportunities for the maritime sector to capitalize on those advantages. An example was applied in the chartering sector, particularly in maritime business chartering and voyage operations. Big data is currently used to manage ship sensors and predictive analysis, which is necessary to prevent delays and improve the overall operational efficiency.

Many processes can be optimized by integrating this technology, such as optimizing the vessel's route and tracking technologies. A process of information can provide an insightful forecast for the most efficient route for a vessel to travel through. As well as tracking either containers and cargo or other logistic operations can help miscommunications, loss of cargo, and issues with dispatch. Better and more efficient organizing and distribution will be provided, specifically for larger and active ports. This information for the shipping industry can use to make decisions in the near future to predict, thus avoiding costly problems and creating more reliable cargo delivery options.

Another critical factor to consider is the emergence of artificial intelligence and the changes that have started. The pairing of both innovations will break down four significant sectors that the future will make sure to be applied in the maritime industry. Those are digital transformation, big data applications from the AIS, energy efficiency, and predictive analytics. (Shaini - Digital solutions for logistics 2020)

Big data, as stated previously, provides multiple advantages in terms of the operations conducted in the maritime sector; Specifically, either towards the reduction of operating and fixed costs of a shipping company or increasing quality and efficiency to providing services. Thus, creating opportunities and providing for the growing demand of the market.

An essential application of big data refers to the optimization of logistics. For the stakeholders and the charter party, it is vital to provide the corresponding information prior to arrival, for instance, more documentation. Providing the ability to monitor the coordinates of the vessels, port managers can minimize the time that ships will be mooring and conducting various activities and minimize high vessel traffic and queues.

Another application is related to the economic and environmental sustainability of a company's vessel. With the plethora of data and analysis that can occur, the monitorization of fuel consumption and travel distance can automatically be corrected without the intervention of the operational management of the vessel. Moreover, with the new environmental regulations being adopted by IMO, an automated system can provide accuracy and reassure that the set terms are being followed.

An issue worth noting is the safety of ships. Significant improvements can be made through applications, for instance, the automation of detection malfunctions. Introducing techniques such as machine learning, data from all parts and systems of the vessel, and after being vigorously analyzed, will provide instant detection without any human intervention. An example is a collaboration on SAFER's project between IBM and the Port of Singapore in 2019. Through big data and machine learning, they could detect suspicious and unusual behavior on the vessel.

The requirement of digitalization of the maritime industry has been at the center of attention for an extended period. Mainly referring to day-to-day operations, the abilities of growth lies in the increase of revenue and the maximization of the quality and quantity of the providing services. However, to achieve all of the above, innovative and disruptive strategies must integrate new concepts, technologies, and goals. Such examples can be the Internet of

Things (IoT) and Artificial intelligence. Therefore, digitization will come one step closer to projects that involve autonomous ships and green shipping.

3. The importance of Blockchain and its application in the maritime sector.

The shipping industry is known for the globalized scale it operates on and has needed digital transformation procedures. Disruptive technologies, such as those studied in this paper, can provide a much-needed change for the sector in total. Blockchain is one innovation worth noticing; even though mostly theoretical applications are explored, there are signs that a significant improvement in various processes can take place, not only for a shipping company but mainly referring to the companies and organizations supporting the maritime industry, such as logistic centers, classification society and, even flags. Therefore, the shipping industry needs to re-organize and re-evaluate its strategies by examining and integrating as many applications as possible.

Since blockchain technology is still in its early stages, it can be approached with how it possibly helps us rather than how we make our issue fit into the blockchain technology. Blockchain technology should be seen as any other technical solution at an organization's disposal, and it should only be used in appropriate circumstances. A well-known example is modern cryptocurrencies, built on blockchain technology and renowned for the substantial use of cryptographic functions. To digitally sign and safely transact inside the network, users use public and private keys.

Contemplating organizations adopting blockchain technologies should be aware of the technology's fundamentals. When a company installs a blockchain network, it can make further adjustments to the data stored, assuming that the company was not satisfied with its initial database. When using a database, a change could be made in the existing data by using a database query and update. Organizations must recognize that while modifications to the underlying blockchain data can be minor, they may significantly impact. Since using the Blockchain as a data layer is daunting, applications get around this by treating later blocks and transactions as changes or improvements to earlier blocks and transactions.

This program abstraction allows changes to working data while keeping track of change. Another essential feature of blockchain technologies is how users agree on the validity of a contract. This is referred to as "finding consensus," and several methods achieve this, each with advantages and disadvantages for specific market situations.

Blockchain applications are sometimes created with a particular goal or feature in mind. Cryptocurrencies, smart contracts (software deployed on the Blockchain and implemented by machines running the Blockchain), and distributed ledger structures for companies are all examples of functions. The world of blockchain technology has seen a steady stream of advancements, with new platforms being revealed regularly; the environment is continually shifting.

It has been noticed that the maritime sector is reluctant to changes. New technology adoptions concerning improving the workflow onshore and the services assisting the vessels are not early adopted unless the new technology concerns the vessel itself. The risk-averse mentality of the sector may result in more significant losses in the long run.

3.1Fuel Quality Traceability and Assurance.

Shipping emissions significantly impact the environment by causing air and water pollution, which resolves in marine life being damaged and climate change provoked (IPCC, 2014; NASA, 2020). Pollutant emissions from burning fossil fuels in the maritime sector are

the root of thousands of premature deaths every year due to various chronic health problems that arise from exposure to toxic and hazardous substances such as sulfur oxides, nitrogen oxides, and particulate matter emissions (Corbett et al., 2007; Winebrake et al., 2009; Sofiev et al., 2018). There are initiatives from IMO to establish new regulations to address these emissions. These initiatives aim to reduce the volume of carbon emissions by 40% until 2030 and 70% by 2050, respectively. In addition, IMO wants to reduce greenhouse gas emissions by at least 50% by 2050. These reductions refer to the level at which the measurements were in 2008. The new regulations' implementation, tracking, and enforcement present many challenges since IMO does not have established authority to enforce. Monitoring, tracking, and enforcement are under the Flag States and Port states (IMO 2019). As a result of the established system, compliance is inconsistent among nations, even those which desire to enforce the rules.

To begin with, plenty of opportunities exist for non-compliant ships to go unnoticed, as only an insignificant percentage of ships tend to be inspected at a port in a vast majority of countries (e.g.,2-7%). The statutory penalties for violations vary significantly from state to state. (Konotey-Ahulu, 2019). Secondly, the lack of documentation around fuel quality presents a challenge concerning insurance claims. Fuel purchasing is not accompanied by access to quality assurance data with fuel production and processing (MacDonald 2018a).
A great example is if the shipper is to receive the contaminated fuel, the insurance company will not access the data to prove its compliance or show that the contaminated fuel is used. The paper-based bunkering system utilized by the bunkering industry is incapable of providing quality services due to its outdated structure. The adopted system cannot deliver reliable tracking, tracing, and the fuel's assurance of origin and quality. Thirdly, the adopted system leaves room for fraud, but at the same time, the system does not allow involved parties and stakeholders (e.g., insurers and regulators) to have access to data regarding fuel origin, supply chain, and combustion.

The solution to these problems may be solved by the opportunity that blockchain-based systems provide. The ability to record all the necessary information and data is gathered throughout the bunker fuel supply chain on a distributed ledger. In this way, interested parties could easily view data in searching to verify compliance with insurance contracts or regulations.

3.2 Bills of lading

Bill of Lading (B/L) is one of the most crucial and used documents in the shipping industry that contains essential information needed for freight to complete its purpose. Additionally, B/L is proof of ownership (or title) of goods that are transported; as a result, the identity that holds the B/L is the owner. B/L is a usually paper-based document, and due to the nature of the system, delays often occur because of lengthy processing and physical delivery time (Czachorowski et al., 2019; CargoX, 2018; Reed Smith, 2016). In addition, B/L burdens the environment by requiring adequate resources, leading to the deforestation of thousands of trees cut annually to produce the necessary copies (CargoX 2018). It is estimated that around $7 billion is spent each year for transportation and printing the bills of lading (CargoX 2018). Furthermore, a concern around B/L is fraud, which includes inaccurate descriptions of cargo, counterfeit signatures, counterfeit corporate stationery, or the usage of corporate logos on fabricated documents (Czachorowski et al., 2019; CargoX 2018).

In the shipping industry, the interest for electronic bills of lading has been on the rise, with currently a shortlist of renowned organizations being authorized to supervise the procedure. However, the adoption of electronic B/L systems comes with challenges such as security risks, the ability to duplicate forms, ensuring its authenticity, and the issues that arise from a centralized system operated by an administrating/operating company (Winebrake et al., 2020;

CargoX, 2018); with little to none charter party agreements to include the clause relevant to the digital version of BoL.

The endorsement of Blockchain systems may be a solution to many of the challenges that come with paper and even electronic Bills of Lading by providing an immutable, traceable, and decentralized platform for this documentation, accessible by the interested parties. Some promising initiatives in this area exist, such as CargoX and TradeLens.

3. 3 Ship's operations.

Ship operations require a plethora of procedures, all the issues mentioned before face challenges or are inefficient, which may lead to severe problems and malfunctions that can damage the vessel to a great extent and cause problems to the procedures carried ashore.

Every transaction usually creates a significant amount of papers such as charter parties, letters of credit, bills of lading, and customs clearance documents. Typically, these paper documents are physically transported and require passing through numerous stakeholders' lengthy chain of inspections for approval, processing payments, or customs clearance. This process is susceptible to fraud, human errors, and unintended delays (Lam and Zhang 2019). Longman (2017) noted that paperwork costs were 15% to 20% of the total shipping fee. Moreover, the documents process was approximately 29% of the total delivery time from exporters to retailers (Park, 2018).

Taking all the above into consideration, there is an opportunity to increase efficiency and decrease costs in shipping by reducing paperwork. This opportunity may be taking advantage of Blockchain, which can solve this problem in several ways. Firstly, it can provide a paperless, tamper-proof process, using public and private keys for a safe environment to communicate, transfer documents, execute payments, and perform transactions. Secondly, the adoption of smart contracts could provide an independent and safe environment for players to negotiate prices directly on the blockchain network. Thirdly, Blockchain bestows full transparency in business, any information on a ledger can be visible to all the accessing parties in real-time.

Numerous studies point out that efficient information sharing can significantly increase the overall operations performance and the supply chain integration (Prajogo and Olhager 2012; Lai, Wong, and Lam 2015). According to Seatrade (2018b), shipping costs could decrease up to $300 per container if the information is shared effectively. In addition, only from sharing container capacity, the container industry expects to save nearly $6 billion and lessen about 4.5 million tons of CO2 emissions every year (Lewis, 2018). Nevertheless, the main obstacle to sharing information has been the lack of trust among the companies (Wu, Chuang, and Hsu 2014). These problems could be addressed with Blockchain by building trust among users (Kshetri 2018). This is possible through reliability, responsibility, predictability, and data integrity (Beck 2018). Moreover, Blockchain can provide financial, informational, and operational shipping data in a global platform and provide security of data storage and transmission (Tan, Zhao, and Halliday 2018). Also, Blockchain grants real-time updates of information, and the records are transparent and immutable.

One major challenge in logistics is monitoring product quality and tracking their location until delivered to the end-users (Shankar, Gupta, and Pathak 2018). The current systems do not provide reliable and real-time shipment tracking throughout the transportation phase (Wu et al., 2017). This leaves room for fraud that may lead to consequential financial losses to honest companies (Kshetri 2018). Blockchain could refine the established tracking system in supply chains by storing a traceable and unmodifiable record of cargo movements from sender to receiver on a real-time basis. Each product is provided with a unique ID and scanned on every transportation stage, then the scanned data is uploaded in a distributed ledger and can be accessed by the involved parties in the transaction chain.

3.4 Ship finance

Ship finance is divided into three main applications, ship Financing, cross-border payment, and escrow. Traditionally shipping companies have been financed by banks (Kavussanos and Tsouknidis 2016). Most banks that are oriented towards the shipping industry have already abandoned the sector. Only a few still are investing in their shipping loan portfolios but have limited their funds towards the shipping industry due to strict financial regulations such as Basel III (Lozinskaia et al., 2017). Even though shipowners have been raising funds by Initial Public Offerings (IPO) or issuing bonds in capital markets (Albertijn, Bessler, and Drobetz 2011), this method does not suit the majority of shipping companies because they are comparatively small in capital markets (Stopford 2008).

Blockchain technology can provide a replacement, the Initial Coin Offering (ICO). ICOs are carried out in a blockchain-based trading platform by issuing cybernated tokens. ICO is very similar to IPO; however, ICO has considerable advantages. ICO makes cross-border transactions smooth and easy, provides transparency and liquidity, and, more importantly, it cuts intermediaries.

The second problem regarding ship finance is the inefficiency of cross-border payments; cross-border transfer costs are 5%-20% of the total transaction (Martin, 2017). Using cryptocurrencies, the cost can be decreased to 2%- 3%, and the payment is completed in real-time (Martin 2017; Yuan and Wang 2016). Furthermore, each transaction can take up to a few days to get to the designated bank account. Blockchain provides an environment with faster, cheaper, and safer alternatives for cross-border payments than the traditional SWIFT systems (Yuan and Wang 2016).

Lastly, due to many implications that can arise during a cargo transfer, the use of escrow services is essential. The properties of cryptocurrencies with intelligent contracts could act as a trustful escrow account for solving managing deposits or disputes. For instance, flaws in container booking can lead to defaulting problems, which can be solved by using blockchain structure. No matter who is responsible, the deposits will automatically take place under a smart contract. If a booking is fulfilled successfully, the deposits will correspondingly return to the parties (Wainwright 2018).

3.5 Marine insurance.

Blockchain can improve three areas in the marine insurance and reinsurance industry, specifically towards fraud reduction, underwriting, and claim management. Fraud generally is a severe problem in the insurance industry (Henry and Hogan 2018). This problem could be solved by using a blockchain system, which provides cryptographic authentication and data transparency. In detail, by using Blockchain, insurers could verify identities, recognize double claims, identify patterns of fraudulent behavior. (Henry and Hogan 2018).

Underwriting is the process by which an institution takes on financial risk for a fee. For a proper evaluation of the risk to be made and in a short time, big data is needed. With Blockchain, the process can be simplified since the necessary information on the ledger remains verified, stored and the record of applicants for insurance policies can be effortlessly followed (Nath 2016).

Many parties are involved in processing insurance claims, including policyholders, insurers, and other third parties. However, the transparency of necessary details to process claims is currently inadequate (Nath 2016). Claiming processes can be done on equal footing

by utilizing Blockchain, which can provide a transparent platform on which all the supporting documents will be stored and easily accessed by the involved parties.

4. Blockchain protocols

Different parts of Blockchain are maintained via blockchain protocols. A protocol is a set of rules and instructions for completing a specific activity. The protocol's goal is to create a framework containing rules and standards for internet data transport. These criteria are required in order for data to be transmitted efficiently. There are blockchain security protocols, network protocols, and consensus protocols, for example. When all of these protocols are integrated, they form a blockchain foundation. In this paper, three main protocols will be analyzed: Proof of Work (PoW), Proof of Stake (PoS), and Proof of Authority (PoA).

4.1. The Proof-of-Work Protocol

The Proof of Work (PoW) protocol is one of the most well-known methods regarding a blockchain system to achieve digital transactions in a safe and protected environment, avoiding malicious and unwanted actions that can cause dysfunctions in the system. The specific protocol constitutes the basis of the largest cryptocurrencies (by Market Capitalization), named Bitcoin. It is cost-effective to avoid denial of service attacks and other network abuses like spam by requiring some effort from the service requester, generally in computer processing time.(Frankenfield, J., 2021)

Proof-of-Work(PoW) is a well-known technique for rationing resource access in client-server relationships. It is set to resurface to ensure the integrity of a global state in distributed transaction systems under decentralized management. Mining is one of the essential principles in PoW; It is the process of verifying all monetary transactions to generate cryptocurrencies as a reward. Furthermore, PoW mining is the process of adding transaction records to the public ledger of previous transactions. The Blockchain is a series of blocks that serves as a ledger of past transactions. In order for these transactions to be successful, they must be validated by the system and safely restored afterward so that each user can confirm whether a transaction has taken place or not.(Coinbase 2021)

Pow protocol uses proof from the miners, which indicates that they have invested a significant amount of hashing power in a block and, on a secondary basis, can join the rest of the chain from similar blocks, as long as it has fully validation required by the system. However, various disadvantages should be considered, as they can create irreversible damage to the usage and capitalization. Perhaps, one of the most severe and negative impacts that can emerge refers to the immense energy consumption, which is used to fuel the miners hashing power, with numbers that can reach up to 125 TWh per year, reflecting the numbers of Argentina’s energy consumption. Furthermore, aspects show that environmental politics regarding energy consumption can create a constantly pressing legal framework requiring highly advanced solutions, such as renewable energy sources. Finally, another major drawback is the manipulation that one can create by owning 51% or more of the Cain,

controlling most network nodes. Nevertheless, it could be plausible to manage the chain to their advantage through canceling or preventing a given transaction and accepting another one with higher profit margins. (Hetig, A., 2020)

4.2.The Proof-of-Stake Protocol.

On the other hand, Proof-of-Stake (PoS) protocols were created as a low-energy alternative to Proof-of-Work (PoW). Although PoW was the first step towards the usage of Peercoin, the first Proof-of-Stakes (PoS) network was created to reduce PoW's computing needs and make better use of the computational resources. Considering this, the main difference between PoW and PoS underlines the process that blocks and transactions are carried out.

Participants with more remarkable coinage are estimated to have a better chance of being chosen. Peercoin's nodes solve a PoW puzzle of their difficulty, which may be lowered by eating coinage. Solution searching is no longer used in modern PoS networks, and block leaders are no longer chosen based on computing processing capacity. Instead, they are chosen depending on the amount of money at risk. With the stake-based leader selection process, a node's probability of being chosen as a leader is no longer determined by its processing capacity, and therefore PoS methods consume substantially less energy than PoW processes. Moreover, because miners suggest many alternative blocks, the PoW networks keep block creation and transaction confirmation speeds at meager consistent rates to maintain security. As only one block is created in each round of PoS methods, block creation and transaction confirmation times are significantly faster, and as a result, PoS mechanisms have lately gained popularity.

In the PoS blockchains, leaders of each block are chosen based on their stake contributions to the blockchain network rather than computing power resources. The node's stake, especially in the PoS consensus process, is the number of digital tokens it owns or deposits. Instead of wasting much energy seeking a new block like in PoW, a leader will be chosen to execute mining and create a new block based on its stakes. (Oliver Kattwinkel)

Many PoS based blockchain networks, such as Cardano and Tezos, have implemented the Follow-the-Satoshi (FTS) algorithm to replicate the stake-based leader selection process. All tokens in these networks are indexed. The FTS algorithm is a hash function that accepts as input a seed (a string of any length, such as the preceding block's header or a random text generated by some other nodes). Following this, the FTS algorithm generates a token index. The algorithm scans the transaction history using the index to discover and choose the current owner of that token as the leader. PoS techniques have a quicker transaction confirmation speed than PoW processes, in addition to the advantage of low energy usage.

Confirming a transaction in a blockchain network is determined by two primary factors: transaction and block confirmation time. The transaction throughput is the number of transactions per second (Tx/s) that it can handle, which is critical to the network's performance, especially when there are numerous pending transactions. The Tx/s specifies how quickly a transaction is added to the chain, whereas the block confirmation time specifies how soon the transaction is confirmed once it has been added.

Many variables influence the security of PoS protocols. Because voting rounds mimic the leader selection procedures, when voters broadcast their ballots to other participants, network synchronization is critical to the security of many PoS protocols. Because network

latency and connection complexity make it impossible to ensure that all messages are transmitted correctly in practice, network synchrony must be considered while assessing the protocol's security. Some PoS protocols are secure when the network is partially synchronous, meaning that messages sent will arrive at their destinations within a given amount of time, or asynchronous, meaning that messages may not arrive at all. In addition to network synchronization, the incentive mechanism is critical to the security of a PoS consensus process. Both reward and punishment systems are often used in PoS protocols. (Cong T. Nguyen 2019)

4.3.The Proof-of-Authority Protocol.

Proof of Authority (PoA) is a reputation-based consensus method for blockchain networks that provides a realistic and efficient solution. Ethereum co-founder and former CTO Gavin Wood coined the phrase in 2017. The PoA consensus process makes use of the value of identities, which implies that block validators stake their reputation rather than coins. As a result, validating nodes that are randomly picked as trustworthy individuals protects PoA blockchains. The PoA architecture relies only on a small number of block validators, so it automatically makes it a very scalable system. Pre-approved individuals, who function as system moderators, verify blocks and transactions.

The PoA consensus method is a high-value choice for logistical applications and may be used in many circumstances. For example, PoA is seen as a viable and cost-effective option when it comes to supply chains. The Proof of Authority approach allows businesses to preserve their anonymity while using blockchain technology's advantages.

The PoA consensus mechanism is typically based on authentic and trustworthy identities, difficulty in becoming a validator, and a `criteria for validator acceptance; however, the prerequisites may differ from system to system. Validators must verify their true identities, and candidates must be ready to pay money and risk their reputation. A rigorous procedure eliminates the risk of choosing shady validators and encourages long-term commitment. Last but not least, all validators must be selected using the same approach.

The assurance of a validator's identification lies in the heart of the reputation system. This can not be a simple procedure, nor can it be quickly abandoned. It needs to be able to filter out bad players. Finally, ensuring that all validators follow the same method ensures the integrity and dependability of the system.

The PoA method is thought to obviate the need for decentralization. As a result, one might argue that this consensus algorithm paradigm simply makes centralized systems more efficient. While this makes PoA an appealing solution for huge businesses with logistical requirements, it does raise particular concerns, particularly in cryptocurrencies. Although PoA systems have a high throughput, immutability features are called into doubt when filtering and blacklisting are simple to implement.

Another common objection is that anybody may see the identities of PoA validators. The counter-argument is that only established actors capable of maintaining this position would aspire to be a validator (as a publicly known participant). However, knowing the identity of the validators might lead to third-party manipulation. For instance, if a rival wishes to destabilize a PoA-based network, he may try to persuade publicly recognized validators to commit fraud in order to undermine the system from the inside.(Binance Academy 2018)

5. Challenges, Barriers, and Concerns Surrounding Big Data and Blockchain in the Marine Sector.

5.1 The challenges of adopting Big Data.

Big Data has a significant impact on telecommunications, financial services, healthcare, logistics centers, and others. The marine sector has proven to lack prompt adoption of this technology due to the nature of the industry. Big data has created many challenges, primarily due to the lack of appropriate infrastructure to manage and analyze the volume of data collected by multiple sources.

6. Data Quantity and Quality.

Indeed, a significant issue regarding the application in the maritime industry is data quantity and quality; as stated in the characteristic 5 V's, these are vital parts of Big Data. Shipping companies base their strategic decisions on large volumes of daily data to minimize risk, alleviate the cost, and maximize productivity. With modern technologies throughout the ship and its related procedures, data collecting has created issues regarding the procession of data and the identification of valuable excerpts.

For this reason, the data may denote quality issues. The most common problem is duplicate data; specifically, the same record passes the system twice or more, creating copies that consume storage space and may be inaccurate (Koumarelas, Jiang, Naumann,2020). Another issue is that the manual entry of data into a computer system can cause errors as these may be inaccurate according to the data needed by the algorithm. In addition, there is a possibility to have low-quality instrumentation, especially on older ships. In other words, when there is an old ship that the shipping company does not use operationally very often, there is a possibility some of the sensors are dysfunctional or disconnected and, in this way, either incorrect data will be recorded in the system, or these data will be incomplete. As a result, the company will not be able to exploit the essential information.

6 .1 Storage and Data Transfer.

The shipping company should also find a way to deal with data sorting and storage to extract the valuable information it needs. For this reason, it requires a sufficient and large capacity database to securely gather all these data until the moment to be reused. If a shipping company does not store these within a certain period of time, they will be permanently deleted.

It is worth mentioning that to store all this data; the company must take care of another problem, which concerns the communication between the ship and the shore. In order to attain that, the shipping company must use specific satellite communication equipment which will have the ability to transfer data from enormous distances but with limitations in maximum available bandwidth (Maris Mirović, Mario Milečević, and Ines Obradović, 2017).

These pieces of equipment have high purchase costs and extended maintenance costs burdening the company's budget.

6.2 Security and Privacy.

Security and privacy constitute another critical challenge for the maritime sector. Physical network connections can provide an access point to crucial information and can be taken advantage of. The lack of proper development and adoption of infrastructures capable of providing the much-needed security creates a distinctive vulnerability in the systems against
Cybercriminals (Maris Mirović, Mario Milečević, and Ines Obradović, 2017). According to Lloyd's Register Foundation (LRF), when an individual without permission inserts, updates, or deletes a device's data, then there are security issues to the infrastructure. Consequently, the shipping sector must provide solutions to ensure that unauthorized people will not access important information.

6.3 Ethics and Data Governance.

Furthermore, ethical issues are also an essential aspect of Big Data since more and more data is being processed daily. To illustrate, the maritime field has not enacted a precise legal framework yet (Maris Mirović, Mario Milečević, and Ines Obradović, 2017). Thus, the companies are unaware when a section of information can be legally transparent or not. In addition, since the algorithms are becoming more complex and autonomous, shipping companies should be more responsible and cautious when these data represent an individual's rights. Also, according to the authors, the maritime institution Det Norske Veritas - Germanischer Lloyd considers that it is necessary to establish proper governance for issues related to these data since there are many stakeholders with different property rights.

6.4 The monopoly of Data Providers.

Last but not least, data should not be monopolized by a specific group of companies in the industry. Each company must use the recorded data to benefit from the information provided. The accumulation of big data can be disastrous as it will create a gathering of market power to specific groups. In an event like that, the possibility of exchange and leak of sensitive data between companies is higher than ever.
Hence, the shipping sector is required to manage this challenge of monopolistic deals with providers to ensure the appropriate conditions among industry competitors (Sadaharu Koga 2015).

6.5. The challenges of adopting Blockchain.

The use of blockchain technologies is not a panacea, and questions such as how to cope with unauthorized users, how restrictions are implemented, and the shortcomings of applications, must all be addressed. There are organizational and governance problems that concern the network's actions and the technical issues that must be considered.

There are already a plethora of initiatives and conceptual frameworks surrounding blockchain technology in the maritime sector. However, most of the initiatives are at a pilot or

introductory phase and are implemented on private platforms among a selected or limited group of participants. The fact that large-scale implementation of Blockchain is still not attainable is associated with the complexity and concerns of the sector and the shipping industry's culture. Following this statement, the challenges will be presented.

6.6 The culture of the Shipping Industry.

It is well-known that the maritime sector is characterized by circularity and small profit margins or no profits at all for long periods. For this reason, the shipping industry is risk-averse and tends not to invest early in new potentially risky technologies. Provided that technology has a proven track record, supporting infrastructure and systems in place, and only on this occasion, the shipping industry is considered investing. Therefore, the reluctance to innovation leadership may entail a transformation in perspective.

6.7 Security, Safety, and Privacy.

According to Werbach (2018), Blockchain-based systems promote safety and security but remain vulnerable to some extent. For example, in May of 2020, multiple supercomputers across Europe were infected with mining malware. Considering such incidents and the emphasis that the maritime industry takes seriously matters regarding safety and security discourages the adoption of Blockchain. Information on specific goods and positional data may be viewable to third parties that do not belong inside the shipping network. The positional data in combination with the information of a high-profile cargo might be taken advantage of for malicious actions (e.g., piracy), leading to serious safety and public health risks.

Although security and safety are crucial in the industry, the majority of the stakeholders are concerned about privacy. In recent research, which involved interviews of stakeholders in shipping companies, the participants pointed out that data protection is crucial for keeping a competitive edge, as "competition is fierce" (Ytterstrom and Lengerg, 2019). The leakage of a company's sensitive information could be extorted to damage its integrity and quickly call forth its closure since the maritime industry is not forgiving and works with a trust-based system.

6.8 Data Tampering.

As we have learned, Blockchain prevents tampering of files that are already recorded in ledgers; even so, the technology cannot prevent potential data tampering before its registration into the blockchain ledger (Clift-Jennings, 2019). The problem, which arises is driven by the fact that the further a party is (e.g., regulator) from the data source (e.g., documentation of fuel and container's content), the possibility of data alternations increases, even if the alteration occurred intentionally or accidentally (Clift-Jennings, 2019). The previous possibilities could lead to highly severe implications If there is no reliance on blockchain data to validate safety or environmental regulations enforcement. For instance, in case of non-compliance with the regulations (e.g., IMO), sufficient charges may be implied, generating fatal consequences.

6.9 Governance and legal concerns.

The new models of decentralized governance that are being introduced with public blockchains conflict with how the maritime industry operates. Governance is a complicated and vital part of the maritime sector that faces challenges due to the possible legal implications and the already existing barriers around the adoption of Blockchain. Both permission and permissionless ledgers face challenges, for instance, accountability related to terms of use and responsibilities for participants. Maritime stakeholders have been vocal about the need to regulate Blockchain, ownership, and use of data. Moreover, stakeholders have expressed concerns about jurisdiction and how potential disputes would be settled (Wagner and Wisnicki, 2019). Nevertheless, the lack of appropriate and favorable policies restricts blockchain adoption (Savelyev, 2017). Lastly, Goldenfein and Leiter (2018) raise challenges around necessary legal development that is needed for transacting with these technologies.

6.10 Technology Integration and Interoperability.

For Blockchain to be implemented in the maritime sector, there is a need for standardization and interoperability across all the platforms and applications. Currently, this is considered one of the biggest obstacles to using blockchain tools in the industry (Ytterstrom and Lengerg, 2019; Wagner and Wisnicki, 2019). What is more, it has been noticed that the technical infrastructure available in a plethora of geographic regions differs and does not possess the requirements to support blockchain systems (Ytterstrom and Lengerg, 2019) which contributes significantly to increasing concerns regarding the high costs of implementation. The lack of integration is closely related to the nature of the industry's culture, but that may change in the upcoming future, based on the success of the leaders' initiatives (Gausdal et al., 2018; Ytterstrom and Lengerg, 2019; Wagner and Wisnicki, 2019).

7. Qualitative research.

This paper aims to accept and integrate innovative technologies in the maritime industry, providing the studied advantages such as enhanced security and transformation of business processes and examining the barriers that delay the expected results. In addition to the theoretical overview, qualitative research took place; specifically, the research questions set were "What are the actual probabilities of the studied application for both blockchain and Big Data technologies?" and also "What are the barriers and concerns that hinder the integration process for the maritime industry?".

Although digitalization has been an ongoing project for most business sectors, the maritime industry has shown a lack of flexibility and adaptation of new technologies. Seeing the results of other sectors, it is essential that shipping changes its traditional processes and capitalize on the flourishing opportunities. The qualitative research carried out in this paper provides the opinion of maritime experts, overviewing our theoretical research and answering our survey in an interview-based questionnaire. Specifically, our qualifications for the professionals to be in our control group are to have experience in the maritime sector and

knowledge of innovative technologies, especially towards the ones examined in the paper, Big Data and Blockchain. The carried-out research is on a relatively new topic for the maritime industry emphasizing the Greek shipping community; the final number of participants is 4. Although a larger control group was deficient, a broad spectrum of participants' professions was covered, from academic professors to maritime IT experts.

The results as derived from the conducted research mostly covered the assumptions that we had made. Initially, mainly regarding blockchain technology, the shipping industry has not adopted it yet, with the exception of a few examples, while the level of knowledge on this specific subject does not fluctuate in a similar area among the respondents. The main example that is mentioned is a platform created by IBM and Maersk, called TradeLens, which can provide many opportunities for better management of the logistics that are required in order to achieve more complete transportations. Also, the majority of responders believe that foreign shipping is more receptive to the integration of a new technology, in relation to Greek shipping, while the second one must first make sure that a new technology such as blockchain brings a positive impact (value), to the company, before proceeding to any investment. At the same time, some of them express the aspect that blockchain technology can greatly contribute to faster transactions between traders with lower charges, depending on the digital currency that will be used, in relation to the transactions that took place until today. In addition, there will be greater security for companies that use blockchain technology, since the larger the chain of blocks, the more difficult it is for someone to enter the chain and steal elements of it or gain access to 51% of the chain. In other words, the risk of cyber attacks is reduced, where in other cases they could steal important information from a shipping company. Regarding the legal and regulatory framework, the view is that there is no legal framework and at the same time it is not needed, as it will not contribute to the better functioning of the blockchain. In addition, the use of blockchain will significantly help to reduce the paperwork and time required for Bill of Lading, Chartering and Bunkering. However, especially with regard to Chartering, it is a bit difficult for a company to proceed with the replacement of the broker as long as their importance isn't at the same level as the existing technology. About Big Data, it is argued that they will greatly contribute to the digitization of shipping, upgrading the practices it uses, especially for companies that want to take the next step towards digitization while along with shipping companies will develop other third party companies based around logistics. Finally, the majority of respondents answered positively, when asked if they would decide to invest in blockchain technology in its early stages of development.

8. The future trends and opportunities.

8.1. The future trends and opportunities.

The concept, strategy, and use cases for big data have changed substantially across different industries since it first entered the digital landscape. Big data can play a significant role in improving architectural decisions, and by that, we mean, Data collected by sensors aboard ships may be utilized to reveal flaws in a vessel and enhance future architectural designs. By combining big data and artificial intelligence, it is possible to test suggested models without building the ships physically, saving money, time, and resources. Another future trend and opportunity for those who know Big Data is that they increasingly demand

more data. Cloud storage companies such as Amazon Web Services, Microsoft Azure, and Google Cloud will become increasingly important as data develops and evolves. Companies can scale up and become more efficient as a result. This means that more employees will be employed to handle this data, revealing that there will be more employment possibilities for "data officers" to maintain a company's database.

So when it comes to shipping companies, they seek to find people that are experts in the field. Furthermore, we might experience creating new departments within the maritime business that are exclusive for Big Data purposes. "Big data remains untapped in the shipping industry; therefore, there are huge opportunities for innovation, usage, driving optimal performance, and leveraging assets better." Anwar Siddiqui, Advisor to the CEO of Bahri.

8.2 The Palantir Paradigm.

Palantir is one of the best examples of companies that use big data and its applications to the fullest. Palantir is a software company that does data analytics and forms data-driven decisions. The company does not collect, store, or sell any personal data. It simply uses already existing data to calculate through all the possibilities and formulate the most logical conclusion based on that. In other words, Palantir does not control or collect data. Instead, it is a platform that processes data that is given from existing customers. Palantir has three leading platforms. Foundry, Metropolis, and Gotham. Palantir Gotham is a platform mainly built for government defense and intelligence, whereas Palantir Foundry is mainly utilized by corporate clients, such as Fiat Chrysler and Airbus. Lastly, Palantir Metropolis is used by finance-based companies like hedge funds and banks. In further analysis, many maritime corporations can adjust the three main chapters of Palantir to their turnover.

When it comes to Gotham, the primary value that Palantir provides comes from data integration. Essentially, Palantir processes a wide range of sampling data, which expands from spreadsheets created by enterprises to less traditional forms of data like GPS devices, videos, and map imagery. Afterward, all of this data is taken and processed through Palantir's software and individualized for each person. Palantir Foundry works similarly to Gotham. To begin with, the data is analyzed so users can test hypotheses and spot anomalies in data sets. Metropolis specializes in mathematically analyzing the behavior of models (e.g., stock ticks) over time. Metropolis primarily supports aggregate analysis: pick a set of models, time and run sophisticated mathematical calculations over them. It is mainly used in the stock market. Therefore, data collection can be helpful to their stakeholders as they can forecast a stock price and conclude the right decision.

After illustrating all these examples, maritime corporations or even a stock business can use Metropolis as an efficient way to thrive in the maritime industry. To sum up, we live in a world where the rapid rate of technological development and the excessive use of the internet gives us an excellent opportunity to take advantage of these privileges that can be used in favor of stock market decisions and logistics. (channel CNBC 2020)

8.2. The future opportunities and trends for Blockchain technology.

While looking to the far future of blockchain technology is very exciting, new developments are continually hitting the market, offering even more significant and bolder technology applications. Active blockchain networks are bringing genuine transformational

change to a variety of sectors. As a consequence, we believe that four significant patterns will emerge shortly.

As new governance models are beginning to emerge and create new needs, they allow extensive and varied consortia to handle decision-making, permission schemes, and even payments with more efficiency. These newly formed models will aid in the standardization of data from various sources and the collection of new and more robust data sets with the help of Blockchain.

Adjacent technologies will work together with Blockchain to offer a game-changing advantage. Combining adjacent technologies with Blockchain will enable us to achieve previously unattainable goals. More reliable blockchain data will provide trustworthy information and enhance the underlying algorithms. Blockchain will help with the security of that data and the auditing of each stage in the decision-making process, allowing more precise insights based on data that network participants trust.

As we all know, fake data has been an issue from the moment data existed, and with the help of Blockchain, we can create tools to validate fake data sources, and thus, they will be launched soon. Blockchain solutions will utilize validation tools with crypto-anchors, IoT beacons, and oracles. In addition to this, the requirements for increased data protection measures are trying to link digital assets to the natural world by injecting external data into networks. This improves confidence and eliminates the dependence on the submission of human data, frequently susceptible to error and fraud.

Furthermore, Central Banks will expand into wholesale and retail Central Bank Digital Currencies (CBDCs). There is no question that CBDCs will continue to grow in the upcoming year and redefine payments in various ways in nations in Asia, the Middle East, and the Caribbean. In the first place, the CBDCs will witness continuous development in wholesale CDBCs with the first retail CBDC ventures. Last but not least, the tokenization and digitalization of other forms of activities and securities such as central liabilities for treasury bonds will increase interest.

9. Conclusions.

All in all, PoW, PoS, and PoA each have their own set of benefits and drawbacks. It is generally known in the crypto world that decentralization is highly prized, yet PoA, as a consensus method, compromises decentralization to achieve high throughput and scalability. The intrinsic characteristics of PoA systems are in striking contrast to how blockchains have previously operated. Nonetheless, PoA is an intriguing technique that should not be overlooked as an emerging blockchain solution useful for private blockchain applications. In conclusion, in the shipping industry, more suitable seems to be the implementation of a hybrid protocol of PoA with an emphasis on security and protection of publicity.

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