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Blockchain in the shipping industry

A proposal for the use of blockchain for SMEs in the shipping industry

Friedrich Lorenz-Meyer

Dissertation report presented as partial requirement for obtaining the Master's degree in Information Management

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BLOCKCHAIN IN THE SHIPPING INDUSTRY

by

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Dissertation presented as a partial requirement for obtaining the Master's degree in Information Management with a specialization in Information Systems and Technologies Management

Supervisor: Professor Doutor Vítor Duarte dos Santos

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ABSTRACT

The main objective of this study is to address one of the significant challenges maritime SMEs, as well as the whole industry, are facing concerning the general necessity to digitize the global supply chain: the lack of transparent information flows between participants and the non-existing documentation standards. This objective includes a proposal of using blockchain technology for data sharing as a solution to counter this challenge.

To understand how a blockchain-based data-sharing platform would succeed and tackle this challenge, TradeLens was selected as a case study. The literature review has addressed the shipping industry as a whole, blockchain technology, and its features and current initiatives that facilitate this technology.

The case study analysis and discussion focused on the architecture, data sharing model, and standards for documentation as well as challenges associated with the solution TradeLens is offering for maritime enterprises. From this analysis, implications for SMEs have been elaborated. Concluding these implications have been validated through interviews with industry experts and strategic decision-makers in maritime SMEs.

KEYWORDS

Blockchain; Maritime Industry; TradeLens; SME; Case Study

PUBLICATIONS

Before the submission and defense of this Master thesis, one had the opportunity to submit the work developed during the case study research for publishing as a part of a conference paper. As such, this work will be published in the WABlock'22: Workshop on Applied Blockchain: Technologies, Trends, and Application to be held within CENTRIS 2022 - 14th International Conference on ENTERprise Information Systems. The conference is an AIS-affiliated conference. The notification of results is on July 17, 2022, and therefore this thesis will be handed in before the results are being published. If this work is published, this part has to be adjusted.

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LIST OF ABBREVIATIONS AND ACRONYMS

API	Application Programming Interface
dwt	deadweight tonnage
eBL	electronic Bill of Lading
ERP	Enterprise Resource Planning
IMO	International Maritime Organization
ISO	International Organization of Standardization
SME	Small and medium-sized enterprises
TEU	Twenty-foot Equivalent Unit
TMS	Transportation Management System
TOS	Terminal Operating System
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific
WMS	Warehouse Management System

1. INTRODUCTION

1.1 BACKGROUND AND PROBLEM IDENTIFICATION

Nowadays, blockchain is being hyped up as the fifth evolution of electronic data processing (Laurence, 2019). In 2008 a developer, using the pseudonym Satoshi Nakamoto, released a white paper in which he described the basic concept of the blockchain, a peer-to-peer electronic cash system (Nakamoto, 2008). While the basic idea was to establish a system where online payments can be sent without the use of a third party, being completely decentralized, blockchain and bitcoin went to disrupt the concept of money, transfer of value, and the whole financial system. In 2015 The Economist called in their article blockchain “the next big thing” and even compared it to the introduction of the commercial internet (The Economist, 2015). This sparked the enthusiasm of investors, innovators, and technologists worldwide who saw the enormous potential of the digital currency not being controlled by one entity such as governments or banks (Back, 2017). However, the disruption did not stop there, Hermann and Prof. Dr.-Ing. Liggesmeyer (2018) see the sheer amount of opportunity such technology like blockchain is bringing. Blockchain can improve any contract-related transaction, not only in the financial industry but also in mobility, energy, and identification management.

Moreover, while the digital transformation is covering more aspects of our lives every day, digital innovations decisively initiate essential changes while innovation cycles become shorter (Hermann & Prof. Dr.-Ing. Liggesmeyer, 2018). Therefore, to capture the potential of those changes, it is essential to embrace them from an early stage. In a special issue, Beck et al. (2017) investigate the impact blockchain has on the business processes of modern organizations. While they mainly focus on the financial industry, they also touch upon the implementation of blockchain and its application, such as tracking shipping containers and pharmaceuticals to recording gambling winnings. This includes blockchain adoption in supply chain management in the maritime industry.

In 1960 container transport was revolutionized through the introduction of the ISO standard 668 by the IMO. It introduced an industry-wide container dimension standard and improved transportation efficiency by reducing coordination costs (Li & Zhou, 2021). In the time of digitization, the maritime industry must undergo a similar transformation. However, being an industry that is heavily reliant on paper-based documentation, information sharing is very inefficient and prone to errors.

Loklindt et al. (2018) analyze the challenges of physical document exchange in their conference paper. They aim to set specific guidelines that exploit blockchain technology as a solution for the issue. Eight design principles are imposed: immutability, decentralization, security, privacy, compatibility, scalability, inclusiveness, and territoriality. It leads to four potential approaches for the implementation process.

Wang & Qu (2019) aim to clarify the main valuable characteristics for the use of Blockchain in the shipping business, including decentralization, open data, and authenticity of data. Including applications such as smart contracts, fast payments, information sharing, track and trace, and supply chain finance, they are further investigating the implementation of Blockchain in the maritime industry.

Jabbar & Bjørn (2018) introduce an activity on how to implement Blockchain into the shipping domain. They are introducing an infrastructural grind, by which a domain, like shipping, is intersected with new technological infrastructure such as Blockchain. Analyzing their idea of the infrastructural grind will help understand the elements and appropriateness of the consolidation, permeability, and velocity of the implementation of Blockchain. In another paper, Jabbar & Bjørn (2018b) build upon the infrastructural grind and dig deeper into the implementation process of the Blockchain in the shipping domain. It gives further insight into entangled dimensions of the grind and how the dimensions are embedded differently in the supply chain of shipping.

1.2 Motivation and Justification

In early 2017, the biggest shipping company in the world, A. P. Møller-Mærsk (Maersk) and IBM, the then-named leader in blockchain technology (Juniper Research, 2017), announced a joint venture to build an industry-wide blockchain for the maritime industry. Later that year, the Global Trade Digitization Platform (GTDP), TradeLens, was launched (Jensen et al., 2019). The GTDP's primary purpose was to be a secure data solution that facilitates the exchange of documents and increases visibility. For the platform to reach its full potential and develop the wanted network effect, the two companies worked closely with various stakeholders in the ecosystem, like ocean carriers, freight forwarders, ports, and customs authorities (IBM, 2017). As a result, by the end of 2019, the TradeLens platform publishes more than 2 million events per day and has over 175 organizations in their ecosystems, including major players such as four of the six biggest ocean carriers. Like the Korean shipping company HMM, other big shipping companies followed, seeing the potential this emergent technology is bearing and built their own blockchain-based solutions (Braden, 2017).

With those efforts in mind being made by big shipping companies, there are still some doubts within the industry. Skeptics believe blockchain is, in the best case, a slightly more reliable way to track data but could also backlash and result in a less efficient way of keeping the data compared to the current central gatekeepers (Popper & Lohr, 2017). Furthermore, Gardeners 2019 Hype Cycle, an illustration of the maturity and adoption of technology applications and their potential relevance for solving real business problems and exploiting new opportunities, sees blockchain technology in the so-called Trough of Disillusionment (Rimol & Goasduff, 2019). Meaning the blockchain has not yet reached its full potential in terms of being scalable technically and operationally and still needs five to ten years to have a transformational impact.

For now, only major players adopted this new technology. The customers of the blockchain solutions that are being offered in the maritime industry are mainly large enterprises or their subsidiaries. While previous studies have already explored the blockchain application in the maritime industry, the focus of this study is set on investigating the use of this technology by small and medium-sized enterprises (SME) in the given environment. To understand the inherent uncertainty towards a complete industry-wide implementation of blockchain in the maritime industry, this study will push beyond the current adoption of blockchain. Therefore, the following research objective can be derived.

1.3 Study Objective

The main objective of this study is to purpose the use of blockchain for maritime SMEs in the shipping industry.

To justify and discuss the use of blockchain in the context of the maritime industry, it is necessary to assess the current use of already implemented blockchain solutions and projects in the industry, the obstacles those systems may face, as well as the current challenges SMEs need to overcome and lastly to gather information on initiatives that facilitate technological solutions in this context - in essence, explaining the possible benefits of a blockchain solution for SMEs in the maritime industry to overcome significant issues such as the heavy reliance on paper-based documentation. Furthermore, on a subsidiary level, it is also relevant to explain how blockchain would impact the operations of these SMEs. Concluding, the two research questions can be developed:

Why should SMEs in the maritime industry consider the implementation of blockchain to overcome the challenges at hand?

How would a blockchain-based solution impact the information flow of SMEs between stakeholders in the maritime industry?

2. LITERATURE REVIEW

The following chapter provides the reader with context to the research. First, the maritime industry is introduced to familiarize the reader with the research environment; afterward, the technical foundations of the chosen technology will be explained. This will give a greater understanding of the concepts as well as the terminology used. Finally, applications of the chosen technology in the industry at hand will be examined to give a basis for the following analysis.

2.1. The Maritime Industry

The maritime industry is fairly complex, with a great number of different stakeholders and actors that take part in it. Those stakeholders can be divided by their activities into five distinct groups: shipbuilding, marine resources, marine fisheries, other marine activities, mainly consisting of tourism and vessel operations (Stopford, 2009).

Shipbuilding is the term used to describe the engineering science involved in the development of ships, as well as the industry that manufactures and repairs ships. This includes the production of vessels for transportation (cargo and passengers) and military purposes, as well as marine equipment, ranging from propulsion systems to environmental and safety systems or cargo handling (European Commission, 2020). Vessels are mainly produced in facilities that are called shipyards. The dominant shipbuilding nations in order are China, South Korea, and Japan (Japan Association Shipbuilding, 2021).

Marine resources are activities that concern the extraction and utilization of resources won from the marine environment. In the early stage of those activities, the main focus was on the extraction of oil and gas deposits that were lying below the ocean floor (Lange et al., 2014). Nevertheless, the marine resources also include the minerals and the growing industry of renewable offshore production from wind farms, wave energy, and others (Pelc & Fujita, 2002).

Marine Fisheries is a group that includes fishing, aquaculture, seaweed, and seafood processing (Stopford, 2009). The vessels used for commercial fishing vary in size and methods used, from trawling with giant nets to set traps and pots. Environmental hazards like bycatch, reduction of biodiversity, or overfishing are major issues within the industry.

Other marine activities consist of a broad set of different groups. The most significant part is maritime tourism, but this group also includes research, surveys, IT, telecommunications, and marine services. Marine services in specific include insurance, shipbroking, banking, legal services, classification, and publishing (Stopford, 2009), being major stakeholders in the maritime environment.

The last group, vessel operations, is accounted for one-third of the marine activities and includes those which are directly involved with ships. They can be broken down into four sub-groups: non-cargo industry, naval shipping, ports, and merchant shipping (Stopford, 2009).

The non-cargo industry is used in a variety of maritime activities. It reaches from Tugboats that are mainly operating in ports to maneuver bigger vessels through the narrow canals, dredgers that are excavating material from a water environment, or cruise ships and ferries that are transporting people (Stopford, 2009).

Naval shipping has no direct connection to commercial shipping. But the Navy's purpose of protecting and preserving the significant waterways on the oceans ensures the open lines for commercial navigation around the world (Stopford, 2009).

Ports are the crucial connection between land and sea in the maritime environment. The main activity there is to load and discharge cargo from the vessels. Several other vital functions a port needs to inherent are providing a secure location for the vessel to berth, handling different kinds of cargo, providing storage for inbound and outbound cargo as well as efficient integration of land transportation (Stopford, 2009).

Lastly, merchant shipping, which has the most significant share of marine activities with one-third in total, is the service of transporting cargo (Stopford, 2009). However, merchant shipping companies will not use a one-fit-all approach but have to offer a range of transportation services. Those depend on factors like commodity type, cargo size, service required for the transport, amongst others. The United Nations Conference on Trade and Development (UNCTAD) categorized in their annual Review of Maritime Transport (2021) cargo ships by the cargo they transport into five different categories: bulk carriers, oil tankers, container ships, general cargo ships, and other types of ships.

To have a reasonable scope for this research, we will simplify those categories based on the sea transport system by Stopford (2008). The three main categories in this framework are Bulk Transport, Specialized Cargo Transport, and Liner Transport. Those categories will be further explained and set into context in the following section.

2.1.1. CHARACTERISTICS OF THE MERCHANT SHIPPING INDUSTRY

As the previous chapter already gave insight into the many different parts of the general maritime industry, the following will explain the focus of this study, the merchant shipping industry. To have an understanding of the complexity of this specific industry, with its many different stakeholders and activities, the three different categories of transport, by Stopford (2008), need to be assessed in more detail.

The amount of goods being transported best describes the global nature of the shipping industry. In 2020 the industry transported over 10,6 billion tons of cargo, having slightly dropped due to the COVID-19 pandemic from a preceding 11 billion tons in 2019. This accounts for 80 percent of all global trade (UNCTAD, 2021). This shows the undoubtedly central role of shipping in globalization, with major companies in the industry being allocated all over the world, from Asia, Europe, North America, and the Middle East (Stopford, 2009).

The merchant shipping industry is a true enabler for globalization. This is because the shipping companies are closely linked to the companies that produce and use cargo. By sourcing the raw materials where they are cheapest and manufacturing them in facilities based in low-cost locations, the supply chain depends on the ability to move an incredible amount of cargo around the world since these sourcing and manufacturing location are not always located close to each other (Stopford, 2009).

The cargo that is being shipped needs different types of transportation on every other stage their being manufactured or refined. Stopford’s (2007) international transportation system illustrates these changes in transportation requirements. The model divides the cargo transported into three different categories.

Raw Materials - Raw materials are sourced by the four primary producing sectors of the global economy, being energy, mining, agriculture, and forestry. Most of these raw materials need further processing and are transported to processing plants. The main mode of sea transportation is bulk shipping.

Semi-manufactured materials - The principal industries in this second category are oil refinement, chemicals, and steel. Those semi-manufactured materials are then used in manufacturing industries. According to Stopford (2008), the primary manufacturing industries are motor vehicles, light engineering, food processing, textiles, and wood & paper. The goods are still being shipped in large quantities, but the sizes are decreasing while the value of them is increasing. Most of these are being shipped as general cargo, while others like wood are also using specialized ships and cargo facilities.

Final manufactured goods – The final products are shipped to final assembly plants or packaging facilities. From there on, they are being distributed to the end-markets and end-users, including wholesalers, retailers, or consumers.

2.1.2. The Three Types of Shipping

Besides the different types of cargo being shipped, the model also introduces three modes of shipping. Bulk shipping is located on the left side. Bulk cargos are mainly raw materials. Liquid bulk, which requires tanker transportation, are crude oil, oil products, liquid chemicals such as caustic soda, vegetable oils, and wine. The five major dry bulks are iron ore, grain, coal, phosphates, and bauxite, which can be transported in conventional dry bulk carriers. Minor bulk covers the rest of the cargo that is being transported in shiploads - consisting of steel products and scraps, cement, forest products, chemicals, amongst others. The suitability of bulk transport is depended on four main characteristics of the commodity being shipped (Stopford, 2009).

Volume – the amount of cargo must be enough to fill a ship. The amount needed is subject to a great variety of ship sizes in the bulk carrier industry. Reaching from the smallest Handysize Bulk Carriers (starting from 10.000 dtw) to the biggest Capsize Bulk Carriers (over 100.000 dtw).

Handling and stowage – Cargo that is granular in its composition can be easily handled by grabs and conveyers, such as ores or grains, while large unit commodities, forest products like logs, are packed into standard units to increase cargo-handling and stowage efficiency. Cargoes that can be damaged require special facilities, while dangerous cargo, like chemicals, must be carried on a vessel that meets international regulatory requirements.

Cargo-value – low-cost cargo like ores can be stockpiled, while high-value cargo that is more sensitive to inventory costs should be shipped in smaller amounts and there in smaller ships.

Regularity of trade flows – Cargo that is shipped regularly in great amounts provides a better basis for investing in bulk handling systems.

The diversity and variety in commodities and ship size, where each has different requirements and regulations, show only the surface of the general complexity of the bulk shipping industry and should only give an idea of challenges the handling of bulk transportation is reaching. Therefore, this research will not dig deeper into the bulk carrying industry to stay in scope.

On the opposite side of the international transportation system is liner shipping. It accounts for about 60% of the value of the goods shipped at sea (Stopford, 2009). It operates on the model's right side and focuses on semi-manufactured and manufactured goods, also known as “general cargo”. Liner services are defined as a fleet of vessels under common management or ownership providing a fixed service to transport cargo at regular intervals between specified ports (Stopford, 2009). A distinguishable difference between freight-forwarders and logistics providers is that liner shipping is purely focusing on sea transport, while the logistics providers focus is on through-transport management, where third parties are carrying out the transport itself (Stopford, 2009).

Two major differences to the other two modes of sea transport, liner shipping bears are the high administrative costs and the inflexibility (Stopford, 2009). The transport of many small cargo units, containers, in this case, needs more outstanding efforts in organizing its handling, which results in higher costs for administrative resources. Further, being bound to a fixed timetable makes the liner shipping highly inflexible in terms of ports of call and the time a ship can load on and off cargo. These points make a tremendous difference in the business models between the different shipping industries. While bulk carriers are responding to imbalances in supply and demand by laying off their most diminutive efficient vessels, liner carriers are obligated to provide the services according to their schedules, making capacity management one of the critical responsibilities. To overcome this obstacle, liner companies form alliances with one another, operate a joint global service network, and charter space on their vessels to other companies (Stopford, 2009). This results in somewhat greater flexibility to some degree.

The third mode of shipping, specialized cargo shipping, lies in between the liner and bulk carrying. Specialized cargo accounts for cargo that is difficult to handle and therefore needs special equipment or facilities to be transported, loaded, or discharged (Stopford, 2009). The main difference to bulk carrying is that bulk cargo has a near-perfect competitive market where many providers offer to transport the same cargo. The specialized cargo industry, on the other hand, is highly differentiated, where many little shipowners are highly specialized for specific cargo to offer unique handling and storage characteristics. Therefore they are investing in specialized ships and services (Stopford, 2009). The typical cargoes in the specialized segment are chemicals or liquified gases, refrigerated cargos, cars, trucks or unit load cargoes, general cargo that cannot be shipped in a container. Transporting those cargoes is demanding distinct features of transport and have specific characteristics. For example, chemical tankers are subject to immense safety regulations and standards; gas tankers that transport liquified gases need to transport the gases at very low temperatures to keep them liquified; refrigerated ships for perishable goods must compete with refrigerated container services and many more (Stopford, 2009). To go into the detailed characteristics of every specialized cargo would overreach the scope of this research, but there are three main areas in which the ship design can be tailored for a specific cargo. First, improved cargo handling, which allows adjusting the design to improve the loading process of its cargo (Stopford, 2009). The best example is Ro-Ro (Roll-on/roll-off) ships which carry wheeled cargo and have built-in ramps to make the loading process more efficient. The second is improved cargo stowage to minimize deadweight and reduce damages on the ship (Stopford, 2009). Such includes a protective coating for chemical tankers or fitting refrigeration systems. Lastly, the adaptation of integration in the customer's inland transport operations. Being a vital link for manufacturers, some shipping companies enter the terminal and storage operations (Stopford, 2009).

To provide these highly specialized services, it is a necessity to have great expertise in the given sector as well as appropriate management structures. This creates great barriers of entry, resulting in a high concentration of ownership and cooperative arrangements (Stopford, 2009).

All three different categories of the shipping industry are part of the maritime logistics system. Even though they are subject to different challenges, they are operating in the same environment, which will be explained in the following.

2.1.3. THE CONCEPT OF MARITIME LOGISTICS

Logistics, in general, is “the process of managing the flow of raw materials, inventory, finished goods, services, and related information from the point of origin to the point of consumption” (Lee et al., 2010). While maritime transportation is responsible for transporting and handling cargo across the oceans, it is the connection of all trans-oceanic entities in the logistic chain. Therefore, it needs to be adequately integrated into the whole logistics flow to prevent unnecessary costs and delays. This demand for the integration of maritime transportation is bringing up the concept of maritime logistics. Where maritime logistics covers the “process of planning, implementing and managing the movement of goods and information“ with connection to seaborn transportation (Lee et al., 2010). This process is including maritime transportation as well as other additional logistics services.

The following concept of maritime logistics is divided into three essential parts (Lee et al., 2010): shipping, port/terminal operation, and freight forwarding. While the first part of the concept has been explained already in detail, it is also necessary to discuss the other two.

Ports are the ship/shore interface for intermodal transfer or the area with “facilities for berthing or anchoring ships and where there is equipment for transfer for goods from ship to shore or shore” (Alderton & Saieva, 2008) or the other way around. A port is the main link for shipping companies and their trading partners and, therefore, a focal point of connection of seaborne trade with motor- and railways (Alderton & Saieva, 2008).

Ports are one of the most critical links in the maritime transport chain since they are the areas where most maritime accidents happen, where cargo is damaged or stolen, repairs are carried out, most costs occur, shipping services are located, e.g., brokers or agents, surveys, customs, and government policies are implemented (Alderton & Saieva, 2008). The three main features and activities a port is bearing are civil engineering features, sea-land access or infrastructure for berthing, administrative functions, including control of vehicles, all modes leaving or entering the port, ensuring safety and security, immigration, health, customs, and commercial documentation control, and operational functions, like pilotage, tugging, and mooring activities and loading, discharging, storing and distributing of cargo (Alderton & Saieva, 2008). They include a vast and complex range of activities and are therefore way more than just a transport interface. They play a significant role in the efficiency of maritime transport and are required to invest in shore facilities to serve the demand and requirements of different cargoes.

The primary function of the freight forwarder is to arrange the process of international trade. This includes activities such as planning the shipping route, reserving space on a vessel on behalf of the shipper, arranging the payment of the freight, preparing the documents necessary for ocean carriage, e.g., the Bill of Lading, and other documents for customs clearance and insurance. In addition, supportive activities like inventory management, packaging, and warehousing also fall under the tasks of the freight forwarder.

The Bill of Lading (B/L) is one of the most important documents for sea freight transport. It is a document that has been issued by or on behalf of the carrier and signed by him and the shipper. The B/L acknowledges the receipt of the cargo by the carrier in the stated condition and sets out the terms under which he must carry it out. It is to secure the obligation to deliver the cargo to the destination and hand it to the consignee (Schmitz, 2011; Wunderlich & Saive, 2020). It contains information regarding the shipment such as the goods being transported, the vessel on which the transport is carried out, the destination port, amongst others. It is a required export and import document by the customs authorities and inhabits the legal advantage that it can be considered as collateral of carrying goods on board (Ahmadi et al., 2016). For example, the bank can request the bill of lading as a guarantee if the buyer needs to get a loan.

Coming back to maritime logistics, the interactions between the different maritime operators and the inherent value creation are explained with the maritime logistics system (Song & Panayides, 2012). It is based on Porter's (1985) value chain model, as seen in figure 1.

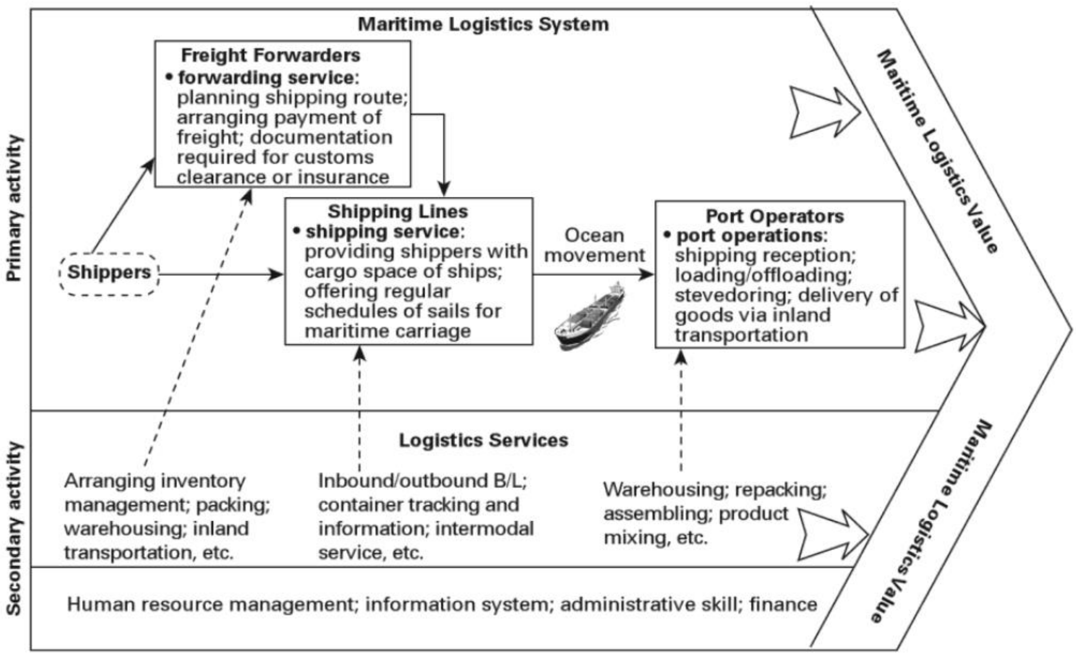

Figure 1 - The Maritime Logistics System (Lee & Song (2010), p.567)

The carried-out activities are divided into primary and secondary activities. The main functions are the primary activities that build the core of the maritime operators where the freight forwarders manage the shipments operations on behalf of the shipper, the shipping line is transporting the cargo, and the port operators load and unload the vessels. The secondary activities have a supportive function and provide a smooth and efficient execution of the primary activities. Further, one can observe that all maritime operators are performing general organizational activities like human resource management, finance, and others, which add to the primary activities as well (Song & Panayides, 2012).

Secondary logistics activities are also often outsourced by the shipper to third-party logistics providers (3PL) (Evangelista et al., 2013). In the early stages of this industry, in 1990, the key activities a 3PL had to offer included transport, warehousing, inventory, but as the industry progressed, the services also included value-added services, information services and design, and reengineering of the chain (Hertz & Alfredsson, 2003).

The activities of the maritime actors are all interlinked within a buyer-supplier relationship. The shipping lines are the main customers of the port operators, of ports their vessel anchor, while the freight forwarders are customers of the shipping lines, of the vessels their use to carry the cargo. Further, those links can be reinforced by additional logistic services of the secondary activities. Therefore, the maritime logistics system offers the greatest value to the customer when all operators are well-coordinated and each individual operator performs efficiently. Ultimately, leading to maritime logistic value.

This concludes the review of the maritime environment in which this research is taking place, giving context to the later investigation. The following chapter will set its focus on the fundamentals of the technology which will be addressed, namely blockchain technology and its characteristics.

2.2. BLOCKCHAIN INTRODUCTION

Blockchain is the underlying technology to this study and the focus for the application for SMEs. Therefore, it is important to get a consensus on the technology, which will be given in the following paragraph.

Blockchain has been one of the emerging technologies in the past years. Receiving great attention in research as well as practical application. To review and analyze this technology, first, an introduction to the basic principles, the architecture, and structure of it will be laid out, followed by challenges blockchain is facing and applications that are using blockchain already.

2.2.1. CONCEPT OF BLOCKCHAIN

The fundamental idea of Blockchain was first introduced by Nakamoto in 2008 as the base for a peer-to-peer electronic cash system, Bitcoin (Nakamoto, 2008). The study proposed this technology where the transaction being made are managed by a collaborative network instead of a central authority or bank. The whole system was based on a feature that needs the digital signature of its peers to verify transactions and an entire audit trail.

From this fundamental idea of blockchain, one can derive three basic concepts of blockchain, the decentralized database nature, the peer-to-peer network, and the three types of blockchain.

When writing his white paper in 2008, Nakamoto wanted to build a decentralized database that is not dependent on third parties. For example, he named central authorities or banks, but with blockchains implementation, those third parties are not only in the financial sector but can reach way further. With blockchain, the necessity for using centralized platforms to channel communication or routing sharing files is obsolete. Decentralized and encrypted communication protocols enable the retrieving, storing, and transferring of data without an intermediate third party, ultimately being a way of data exchange in a secure and decentralized manner. Since the database is distributed not on a single node but is shared among the nodes of the network, there is no single entity controlling or storing the data (A. Hughes et al., 2019).

The traditional database is a client-server model in which data is stored on a single server, where a client can request resources and have them shared only upon request, with a one-to-many distribution system. Here the client is completely dependent on the centralized entity (Jaganathan & Veeramani, 2019). On the other hand, in the peer-to-peer network, the information is not stored on a single server but is distributed on an interconnected network of peers, shown in Figure 2.

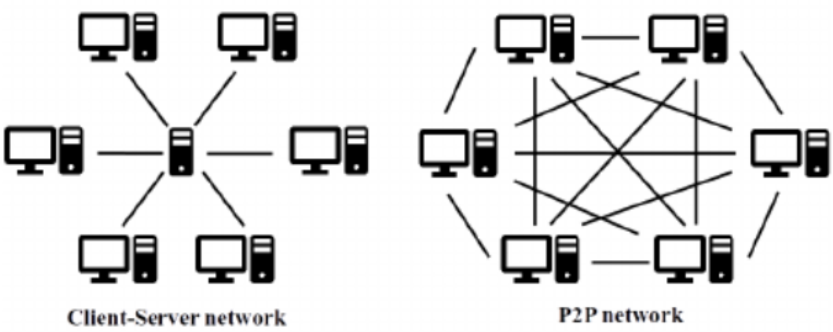

Figure 2 – Client-Server and P2P network modules ((Jaganathan & Veeramani (2019), p.56)

Finally, one should differentiate between three different kinds of blockchain, classified as public, private, and consortium blockchains (Laurence, 2019).

- Public blockchains can be accessed without permission. They are based on an open-source programming code, which is being maintained by the network. Anyone can join the network and participate in the consensus by reading and writing the blockchain data. Most blockchains are public, including Bitcoin and Ethereum.
- Private blockchains, also Distributed-Ledger-Technique (DLT), are smaller and do not use tokens or cryptocurrencies. Participants require approval before they are allowed to join the network. The networked is usually owned by a single entity and is favored by trustworthy notes that handle sensitive data. MultiChain and Blockstake are examples of private blockchains.
- Consortium Blockchains also require the approval of their participants to join the network. The role of each participant is defined. Usually, the network is formed by a group of organizations (a consortium) sharing data but do not trust its members. The networks are extensive and decentralized and use tokens. The programming code can be open-sourced but does not have to be.

All three blockchain types use data encryption to allow their members to maintain the ledger (Laurence, 2019).

Depending on the specific requirements of the business case, developers of a blockchain business model chose the technology for its particular features in terms of decentralized database, peer-to-peer governance, and permission enforcement components (Kostic & Sedej, 2021).

After establishing the basic concept of blockchain, it is important to examine the technologies architecture and its structure further to understand how the technology is being used. Therefore, the following paragraph will lay a foundation on the basic structure and its application.

2.2.2. Structure and Design of Blockchain

The design structure of a blockchain is dependent on the three layers of the system, where the layers are built according to the functionality the blockchain needs to fulfill (Rauchs et al., 2018). Those layers are the protocol, the network, and the data layer.

The protocol layer is the technological backbone of every blockchain solution, being a collection of protocol frameworks (Rauchs et al., 2019). This layer governs through a set of formal rules the architectural design of the system, on which every participant is agreeing upon. The other two layers are built upon the protocol layer. However, being merely a coded constitutional arrangement, it does not bring much value on its own without a network (Rauchs et al., 2019).

The layer above, the network layer, brings the system to life (Platt, 2017). It consists of the interconnected actors who participate in the peer-to-peer network. The protocol rules are practically implemented on this layer by describing the access requirements for participants, permissions for the participants on the data that is shared, updated, and verified within the network (Rauchs et al., 2018, 2019). This produces a single source of truth regarding the shared ledger.

In the final data layer, the information is processed and stored, and is, therefore, the core of the functionality the blockchain is delivering (Rauchs et al., 2018). It is the key user interface and is connecting the business applications to the network using the underlying data, which is being produced, maintained, and verified by the network's members (Rauchs et al., 2019).

All three layers can have a different degree of decentralization, where the governance model of the blockchain can reach from a democracy, where every participant can vote upon the structure of the blockchain, to a benevolent dictatorship, where the founder of the blockchain holds all decision rights over the genesis code and the purpose of the system (Lacity et al., 2019; Rauchs et al., 2018).

The design choice of each of these three layers influences the functionalities of the blockchain system and should therefore always take the use case requirements into account. The design decisions have a direct impact on the level of security, transparency, validation speed, energy consumption (resulting in costs), complexity, and others (Rauchs et al., 2018).

Even though there are different kinds of blockchains with different structures, the Bitcoin-Blockchain is a great example for structure analysis since it is the first blockchain built, and most other blockchains use it as a precedent (Laurence, 2019).

The structure of each block in the blockchain contains, in its essence, a block header and transaction data. The block header includes the block version, the nonce, nBits, the timestamp, the Merkle root, the current block hash, and the previous block hash. As the name says already, the transaction data contains all the transactions of the block (Chen et al., 2020). The block version specifies the block validation rule set, the nonce is used to achieve consensus through the proof-of-work concept is a random number, the nBits is the target threshold of an effective, valid block hash, the timestamp denotes the current time in seconds, and the previous block hash is the value of the previous block (Chen et al., 2020). Figure 3 depicts the general block structure.

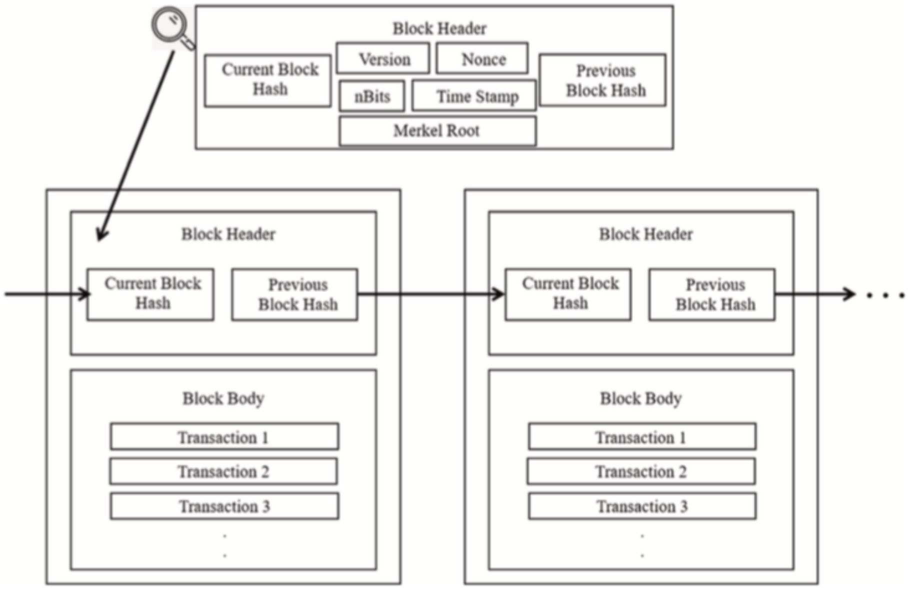

Figure 3 - Blockchain structure (Chen et al. (2020), p. 4)

The primary identifier of the block, the current block hash, is a cryptographic hash, a digital fingerprint. The hash is created by hashing the block header twice through the hash algorithm SHA256 (A. M. Antonopoulos, 2016). The algorithm creates a 32-byte hash and identifies the block uniquely and unambiguously.

The Merkle root of transactions is the summary of all transactions in the block using the Merkle Tree. A Merkle Tree is a binary tree that uses cryptographic hashes to summarize and verify large data sets. By summarizing all transactions of a block, it is producing a digital fingerprint of all the transactions. It is hashing all the transactions in pairs until there is only one single has value remaining, the Merkle Root, see Figure 4. This is a very efficient process of verifying if a transaction is in a block (A. M. Antonopoulos, 2016). This value is then stored in the block header as a 32-byte. The algorithm used is also a double-SHA256.

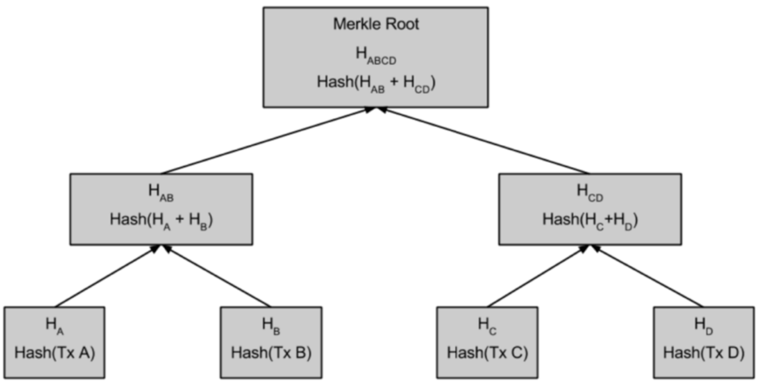

Figure 4 – Structure of a Merkle Tree (A. M. Antonopoulos (2016), p. 171)

2.2.3. BLOCKCHAIN CORE WORKING MECHANISMS

Since the blockchain is distributed, all notes maintain the same ledger. Therefore, all nodes of the network must find a consensus on a new block. Consensus in the network is achieved when a miner is elected by the network and receives the billing rights for a new block. He then adds the block with its transactions to the chain and is broadcasting it to the whole network (Chen et al., 2020). This process for the billing rights is called mining, and the technology enabling mining is the consensus algorithm. There are four main consensus algorithms: Proof of Work (PoW), Proof of Stake (PoS), Delegated Proof of Stake (DPoS), and Practical Byzantine Fault Tolerance (PBFT) (Chen et al., 2020).

Again, the two major blockchains, Bitcoin and Ethereum, are using the concept of PoW. Therefore, this consensus is explained to understand the process behind mining. First, the miner is receiving the broadcasted transaction from the network and verifies that the signature of the transaction is valid. He then composes the transaction into a candidate block and needs to prove the feasibility of the transaction. This is done by solving a cryptographic puzzle, which requires a great amount of computational power to find a random number, the nonce that makes the hash of the entire block in the threshold of nBits. When the puzzle is solved, the miner then broadcasts the entire block into the network. Other miners verify and accept it, and the block is added to the chain (Chen et al., 2020). The miner is then rewarded with Bitcoin when the puzzle is solved successfully, and the block is added to the chain (L. Hughes et al., 2019).

The PoS consensus protocol is an energy-efficient alternative to the original PoW protocol. The miners are substituted with so-called validators, who need to own some assets on the blockchain to verify transactions. The validators offer (stake) their own coins to validate a transaction. If the transaction is correctly verified, the validator receives some respective cryptocurrency as a reward, but if the transaction is falsely verified, some of the staked coins are used as collateral and are taken as a penalty. This is a more resource-friendly protocol since it does not rely on competitive computational power (Morabito, 2017).

The two other consensus protocols are less popular. Where the DPoS is similar to the PoS consensus with an additional voting and delegation mechanism for the network participants to vote democratically amongst the network, the PBFT typically uses participants with register identities and redundant voting to validate new blocks, so attackers have a relatively high barrier to entry and are quickly exposed (Jaganathan & Veeramani, 2019).

2.2.4. CHARACTERISTICS OF BLOCKCHAIN

Combining the unique structure and differentiating characteristics of blockchain enables its transformative power. As the concept and structure of the technology have been established, the following will name four key features – data transparency, security, asset management, and smart contracts (Kückelhaus & Chung, 2018).

Data Transparency - Through the architecture of blockchain, the data that is stored and provided is tamper-proof, accurate and the data source is verified. As a result, every stakeholder in the network receives controlled access to a single source of truth, the dataset, opposite to the traditional multiple parties who have their own datasets, which are being maintained and changed. Therefore, the blockchain-provided data is trustworthy, and every stakeholder can be assured that they receive the most recent and accurate data (Kückelhaus & Chung, 2018).

Security – Nowadays, databases are very prone to cyberattacks like hacking, data manipulation, and falsely incorporated data. Where traditional databases provide only a single layer of security, blockchain technology is more resistant to such fraudulent behavior. The structure of blockchain provides additional security so that every transaction is signed cryptographically. They facilitate profound security and risk management (Kückelhaus & Chung, 2018).

Asset Management – Asset transfer and digital asset management are other features provided through the use of blockchain. The tracking of ownership certificates or rights, reaching from land titles, copyrights to documents like the bill of lading. Further, the technology enables the management of digital twins connected to physical assets (Kückelhaus & Chung, 2018).

Smart Contracts - A concept that was already introduced decades before blockchain is smart contracts. Szabo (1997), known for being one of the leading originators, coined the term as ‘‘a set of commitments defined in digital form, including agreements on which contract participants can enforce these commitments’’. At the time, when blockchain had not made its appearance, the concept was not widely used due to unresolved trust issues (Chen et al., 2020). However, with the decentralization and modification-proof environment that the introduction of blockchain is providing, smart contracts are now being used as commercial and legal contracts. Nowadays, smart contracts autonomously initiate previously contractually agreed-upon actions. For example, agreed payments of sums of money can be initiated autonomously (Meitinger, 2017). When the conditions of the contract have been met, the steps and process steps that were agreed upon are enforced automatically (Kückelhaus & Chung, 2018).

2.2.5. CHALLENGES BLOCKCHAIN IS FACING TODAY

While blockchain is bearing great potential savings through increasing operational efficiency and effectiveness as well as providing the opportunity for new business models, it also faces challenges, like most emerging technologies, that it needs to overcome before reaching its final state of being widely adopted. The most significant challenges will be discussed with a focus on a logistic industry context to stay within the limitations of this paper.

One of the most pressing challenges of blockchain is the general industry-wide adoption. Blockchain will develop its most significant advantage when its network contains all members of a community, where data can be transferred safely and accurately when a full network effect is developed. The value of the network is increasing with the number of members in it. To reach this desired effect, it is necessary to obtain committed stakeholders, whereas the different levels of IT readiness and initial requirements, like the high computational power of those, might impose a hurdle that needs to be overcome. Especially the costs of moving from a legacy system to integrating new technology and system combined with laws and governance will make this transition difficult (Kückelhaus & Chung, 2018).

Since blockchain is an emerging technology, the lack of standards and governance creates another challenge. The competitive nature of business will most likely be the basis for many private permissioned blockchains. Therefore, organizations need to provide and establish standards. This is even more important when it comes to the interoperability between different blockchains. Organizations are already trying to achieve this goal, like the Blockchain in Transport Alliance (BiTA) in the logistics industry (Kückelhaus & Chung, 2018).

Technological limitations with blockchain itself need to be overcome as well. This is necessary, especially when moving from the first pilot deployment to full-scale implementation. There have been examples of blockchain implementations that have scaled poorly and shown high latency, while scalability issues and performance limitations have been addressed through innovative applications. Further, earlier mentioned computational power requirements and the high energy consumption are bringing the entire deployment to a halt (Kückelhaus & Chung, 2018).

Finally, the perception of blockchain needs to change in organizations, and culture needs to change in any industry. To engage a whole network of stakeholders, it is necessary to adopt a collaborative mindset. The success of a digital transformation stands with the culture within an organization of accepting and advocating opportunities blockchain technology offers. Notably, managers must not only gain expertise in the new technology but also proactively emphasize the collaborative concept of the blockchain transformation to flourish its greatest benefits (Kückelhaus & Chung, 2018).

While the named obstacles are just a selection of challenges blockchain is facing, they are not insurmountable. The emerging technology already finds promising applications in a wide range of industries, including the public sector, voting, healthcare management, energy sector, education, data management, supply chain management, and logistics (Casino et al., 2019). The following section will further explore some of these current applications.

2.3. BLOCKCHAIN IN THE SHIPPING INDUSTRY

While the importance and complexity have been addressed in an earlier chapter, and the technological foundation of blockchain technology has been laid out, the following section is now channeling the gained insights. The following will provide not only an overview of the challenges blockchain initiatives are trying to address but is also assessing current projects and businesses that are enabling the technology in the maritime context.

2.3.1. CHALLENGES PUSHING INNOVATION

In their article, Jensen et al. (2019) provide four challenges and their causes in the global supply chain that pushed IBM and Maersk to develop their blockchain initiative, TradeLens. Firstly, each individual organization in the process of shipping is operating its own IT supply chain management system. While there are many different organizations involved in the shipping process, each one of them has its own IT system to track the shipment and the flow of documents. While those systems might have been improved internally, the challenge is associated with the "inefficient flow of inter-organizational, information across supply chain partners" (Jensen et al., 2019). There are no incentives for the stakeholders of the supply chain to share their digital information, especially since most of such is commercially sensitive.

The authors mention that the absence of standardization for trade documents is another challenge. The discrepancies between supply chain partners about the format and interpretation of those documents result in high costs, uncertainty about lead times, and enable severe security risk to the paper-based documentation. These problems have been known for decades, and the EU, as well as the International Organization for Standardization, have made efforts to provide a framework for container documentation standards. But those projects either failed to attract international interest or only have a few participants who have adopted them even partially.

While shipping is expected to move containers from one location to another, it also involves the moving of around multiple documents that need to be updated by multiple parties. Key documents are the bill of lading, packing lists, certificates of origin, commercial invoices, and export licenses (Jensen et al., 2018). Again, the digitization of those documents has been done company internally, but the data exchange in between supply chain participants is rarely done. Therefore, the continuous reliance on a multitude of physical documents is a common practice in the shipping industry. IBM has estimated the costs of paper-based documentation to make up to 15% of the total shipping costs (Groenfeldt, 2017).

The final challenge mentioned by Jensen et al. (2019) is the regulatory requirement of paper documents. Regulations in place require the original document to be signed or stamped to several authorities in short times, up to 15 minutes upon request. The documents are being sent by courier separately while the containers are at sea. If a document is missing or filled out incorrectly, it can delay the shipment's journey. The US Department of Commercer (2018) estimates that the process of documentation, handling, customs clearance, and inland shipping can add over 30 days of delay to the total shipping time.

In 2014, a team of IT specialists at Maersk, have tracked one shipment of refrigerated goods, avocados, and roses, in this case, on their journey from East Africa to Europe. The goal of this operation was to document the complexity of operational processes and the massive amount of paperwork necessary for an ordinary shipment, and the costs of cross-border trade. They found that about 30 people and organizations were involved, with over 200 interactions between them (Bajpai, 2017).

The Allianz (2021) raised in their annual "Safety and Shipping Review 2021" concerns with regards to cybersecurity risk. While four of the largest shipping companies have become victims of cyber-attacks, further concerns are growing about critical marine infrastructure being targeted for further potential strikes.

2.3.2. THE BLOCKCHAIN INITIATIVES

The most prominent example of a blockchain application in the maritime industry is the IBM and Maersk solution, TradeLens. Emerging from their joint Global Trade Digitization (GTD) Initiative, TradeLens was their response to the previously mentioned challenges.

In its early stages, TradeLens was designed to capture and share information about the key events of the shipping containers as well as the providing a network to increase trust and enable encrypted digital copies of trade documents (Jensen et al., 2019). The blockchain ecosystem is connecting all stakeholders of the supply chain, cargo owners, freight forwarders, inland transportation providers, including rail and trucking, ports and terminals, ocean carriers, customs, and other government authorities (TradeLens, 2020a). It provides seamless and real-time sharing of cargo details, trade documents, and shipping milestones, ensuring through blockchain technology that critical information is secure, immutable, and auditable. In addition, the open API environment of TradeLens allows third parties to build applications on the platform.

The different features of the solution are divided into three components: the ecosystem, the platform, and the marketplace. Where the ecosystem ensures the sharing and accessing of the data, the platform is the technological foundation of the TradeLens. The marketplace is the final component that allows as an open application and service marketplace third parties to offer their products.

The joint efforts in the application of blockchain of the two giants were not unseen by others in the maritime industry. HMM, the biggest Korean shipping company and eighth biggest in the world, conducted a blockchain technology integrated pilot voyage, together with Samsung SD, to analyze the potential of blockchain implementation in the shipping industry (Braden, 2017). After finalizing the analysis, HMM announced to continue their efforts on pushing the digital transformation of their company, culminating in the development of cloud-based next-generation IT system “New-GAUS 2020” in 2020 (HMM, 2019). HMM, plans together with the IT provider, Oracle, to rebuild their Global Advanced & Unified System (GAUS) so that the new IT system can manage the data flow of HMM’s vessel operations such as vessel-related information as well as information related to personnel, management, and operations. The proposed system will apply new technologies, including IoT, big data, AI, and blockchain, to provide increased service efficiency and stability of operations.

ZIM, an Israeli shipping company, one of the ten biggest, completed their first pilot testing of a blockchain-backed web-based solution for frictionless digital document exchange called Wave BL (Wave BL, 2017). It enables the instant, encrypted, and authenticated transfer of Bill of Ladings and other vital trade documents.

One of the first startups to introduce smart contracts into the logistics industry was ShipChain. The startup built a comprehensive blockchain system that would track and trace the final product from the moment it leaves the factory till it reaches the final customer. The Ethereum blockchain-based system could encompass all modes of freight. All the shipping information was recorded on the blockchain, and smart contracts could be executed depending on the information recorded. Another key feature of the company was the usage of their cryptocurrency, “Ship Token”, which was used for the automated settlement of transactions (Kückelhaus & Chung, 2018). In late 2020 the company was shut down by the US Securities and Exchange Commission. ShipChain had committed a violation of securities trading laws and could not recover from its sentence (Kingston, 2020).

But also, governmental organizations caught interest in blockchain technology. For example, the Danish Maritime authority launched a pilot project to digitize the ship registration process based on blockchain technology. With the support of Deloitte, they developed a blockchain proof-of-concept and aimed at adapting provisions in the Maritime Act and the Mortgage Bill (Chambers, 2017; Offshore Energy, 2019).

The Belgium startup T-Mining developed a blockchain application for safer and more efficient container handling for ports. The two Benelux ports of Antwerp and Rotterdam are using the method proposed by the company. It replaces the container handling procedure, which involves the usage of

PIN codes, which was in the past subject to fraud, and all associated risks and highly inefficient. T-Mining's blockchain solution uses digital tokens for container release rights, making them much safer, more efficient, and faster (Loohuis, 2020).

As those cases point out, blockchain is arriving in the maritime industry but is still meeting resistance. This study will further examine how SMEs in the shipping industry can overcome this resistance. The following chapter will assess the methodology that is used to discuss the imposed research questions.

3. METHODOLOGY

3.1. THE CASE STUDY APPROACH

Before starting to assess the research methodology of a case study, literature suggests identifying why the chosen methodology has a significant advantage against others (Yin, 2018). The author lists three conditions to be met when choosing a case study, naming (1) the type of research question posed, (2) the extent of control an investigator has over actual behavioral events, and (3) the degree of focus on contemporary as opposed to historical events. A case study should be considered when the research question examines "how" and "why" questions, the investigator has no control over the events, and the focus is set on contemporary events.

To analyze the first condition, one must revisit the initial research question. "Why" would the implementation of blockchain be beneficial for SMEs in the maritime industry, and "how" would the adoption of a blockchain-based solution impact the information flow between the different stakeholders in the maritime logistics system. Yin (2018) suggests in his study that "why" and "how" questions are likely to favor case study research, amongst others, historic and experimental. Therefore, this study meets the first condition to justify the application of a case study as a methodology.

The second and third conditions need to be met to justify the case study approach to differentiate from the historic and experimental research. The contribution to historic research is mainly dealing with fairly old events, meaning no relevant person is alive, and the research must rely on primary and secondary documents, and artifacts as their evidence (Yin, 2018). This study focuses on current events, the current use of blockchain in the maritime industry, which excludes historic research as a methodology. Further, the case study is differentiated from the historic research by the addition of two sources of evidence: direct observations of current events as well as interviewing persons that are directly involved. Both are part of the research strategy in this study.

Experiments are referred to when the investigator can manipulate the behavior directly, precisely, and systematically (Yin, 2018). For instance, in a laboratory experiment where one or two variables are being examined, or a social experiment is done where subgroups are being treated differently to assess their behavior. Although, in this case, the study has no such experimental characteristics, the case of TradeLens will be analyzed, and conclusions will be drawn from its analysis.

Concluding, the present study is fulfilling all three necessary conditions to justify the case study methodology as the most suitable approach to examine, analyze, discuss, and validate possible conclusions.

Yin (2018) mentions and counterargues several traditional prejudices against the use of a case study raised by scientists to justify the case study methodology for future research. To reinforce the decision, in this case, the arguments will be discussed shortly.

The biggest concern is the "lack of rigor" in the case study approach. Not strictly following a structured approach and allowing bias to influence the outcome of a study. This is strictly forbidden when conducting research, but such bias can also enter in the conduct of an experiment, in the design of a questionnaire, or historical research. Yin (2018) realizes that those influences may accumulate in the case study methodology but might be overcome by the guidance proposed in his book. The second concern raised is "the little basis for scientifical generalization". He argues that the case study is trying to expand a generalizable theory or analysis to theoretical propositions instead of particularizing an analysis and enumerating frequencies. The third concern discussed is the time-consuming nature and the length of the data collection. The author disproves this as outdated criticism by explaining that case studies have nowadays formed innovative ways to circumvent such “massive, unreadable documents”. The final great concern addressed by Yin is the unclear effectiveness and comparative advantage against other methodologies. Where randomized controlled trials or “true experiments” have been respected due to their aim to prove the effectiveness of treatments or interventions, they are limited in their explanatory ability of such treatment. At the same time, the case study investigates especially such issues with answering the “how” and “why” (Yin, 2018). The author emphasizes the complementarity of statistical and case study research.

To fully utilize the potential of a case study research and preempt the concerns raised, this study will follow the structured approach with the proposed systematic procedures to overcome any constraints that it might be subject to. The following will lay out a strategy that the research has a basis to become a well-founded and complex investigation.

3.2. RESEARCH STRATEGY

As mentioned in the preceding chapter, case study research needs a clearly structured approach to be successful and scientifically significant. Yin (2018) proposes a research design for case studies to follow through with different steps.

The research design serves in the context of a case study as a logical plan that is guiding from here, the set of research questions addressed, to there, the resulting conclusions that can be drawn from the analysis of those questions (Yin, 2018). The main purpose of such a logical plan is to avoid that the evidence is not relevant to the initial research question throughout the carried-out research. To build the design of the case study, there are five components that need to be taken into account: "study's questions", "propositions if any", "its case(s)", "the logic linking the data to the propositions" and, "the criteria for interpreting the findings" (Yin, 2018).

The previous chapter addressed the research questions already, addressing the “how” and “why”. To support the choice of a research question, it is important to find existing studies in a similar field, in this case, research on blockchain implementation in the maritime industry.

The “study proposition” is the second component of the research design. It is the part that is not only justifying the case study but also the driving force pushing the research to its conclusions. While the “how” and “why” questions are the top part that leads to the case study as the appropriate method of choice, they are not sufficiently explaining the relevance of the study. By addressing these questions about the technology solving existing problems, one can derive a set of propositions. In this instance, one can derive from the question “why” a blockchain solution should be implemented in maritime SMEs that it would overcome challenges posed through the paper-based documentation streams. This proposition could be verified through implications from a role model case.

The third component is the case itself and its identification. This component needs to be carried out in two different steps: the case definition and the bounding of the case. To be able to study maritime logistics systems SMEs and the introduction to blockchain, one should study an example where this has been done successfully already. The case is defined by the real-life situation, the implementation of TradeLens at large enterprises in the maritime industry, while the boundary of the case is the focus on SMEs.

The linking of the data to the propositions is the component that is building the basis for the latter case analysis. The author proposes different analytical methods to represent the linkage between data and the proposition, pattern matching, explanation building, time-series analysis, logic models, and cross-case analysis.

The fifth and final component is the criteria for interpreting the case study findings. While for quantitative studies a certain *p* level proves the statistical significance serves as a benchmark for interpreting the findings, this will not be the case for case studies. The author proposes the identification and addressing of rival explanations of the findings. Meaning the strength of the findings is increasing when more rivals have been addressed and rejected.

After the components have been set, there are a few other theoretical frameworks that need to be discussed before moving forward from the research design, the first one being the theory to generalize from a case study. Yin (2018) differentiates between statistical generalization and analytical generalization. While in statistical generalization, a sample of the analyzed population is used to make assumptions about the population, this will not be feasible in the case study approach. First, because the case study cannot be used as a “sample unit,” and there are too few in numbers to be statistically significant. Therefore, the case should not be used for generalization but the case study, the analytical assessment of the given situation. The case study should be used to point out theoretical concepts and principles. It strives to generate generalizable findings or lessons learned that go beyond the actual case that has been examined. Further pointing out that the findings of the case study are in no way statistical but more like a claim based on an argumentative structure. This argumentative structure should therefore be discussed and not only stated.

Concluding the design phase of a case study research, the author describes the four basic types of designs for case studies. Depicted in the figure, there are four quadrants for each design type: single-case (holistic), multiple-case (holistic), single-case (embedded), and multiple-case (embedded). This study uses a single-case design with embedded units of analysis. The author provides conditions the case has to meet to be justifiable. The case must be either critical of an existing theory, unusual and deviating from the norms, be a common situation, reveal a previously inaccessible phenomenon, or be longitudinal in terms of examining the case in two different points of time. In the chosen case, the first condition is met. TradeLens is an already established blockchain platform in the maritime industry. Further, the embedded design was chosen. Incorporating subunits of analysis enriches the design and increases its complexity as well as generating adding opportunities for the extension of the analysis.

3.3. SEMI-STRUCTURED INTERVIEWS

Yin (2018) sees interviews as one of the key resources during a case study approach. Supporting the research through the explanation of key events and providing insights from an expert’s perspective, the author suggests conducting the interviews in a more unstructured manner than rigid queries. Therefore, semi-structured interviews have been chosen as a method of conduct in this research. Semi-structured interviews have been proven to be versatile and flexible in data collection (Kallio et al., 2016). A significant advantage for the given approach is the possibility of improvising follow-up questions based on the participants' answers to the interviewee. Further, it allows developing a broader understanding of the topic while presenting the questions in a more casual way. The approach requires specific preparation in terms of the knowledge the interviewee has to accumulate as well as preparing an interview guide (Kallio et al., 2016). The guide should offer a focused structure that can be followed but should be enriched with follow-up questions and should not be necessarily followed. Kallio et al. (2016) are providing a five steps guide that will be followed during the process of preparing the interviews. These five steps include "identifying the prerequisites for using semi-structured interviews; retrieving and using previous knowledge; formulating the preliminary semi-structured interview guide; pilot testing the interview guide; and presenting the complete semi-structured interview guide" (Kallio et al., 2016).

In the first step, the appropriateness of a semi-structured interview in the context of the research needs to be addressed. It is suggested by the authors that the given approach is suitable for a research to study the participant's perception or opinion on the given topic. Further, if the participant has little awareness of the topic and to focus on the participant's issues with it, allowing to retrieve diverse perceptions. In the context of this research, semi-structured interviews are being carried out to validate and discuss the findings of the case study analysis.

The second step focuses on gaining extensive and comprehensive knowledge about the subject before the interview. Preparing a pre-interview understanding will provide a conceptual framework that provides the basis for the interviewer's questionnaire. An extensive literature review should be conducted to provide critical appraisal with a focus on the study. As the literature of this study has been provided in earlier chapters, the interviews will be based on this acquired knowledge.

Formulating an interview guide to provide a tool for the data collection in the interview is the third step. It has been defined as a list of questions to steer the interview in the direction of the topic. The questions should allow a dialogue during the interview and needs to be flexible to adjust to the response given. It is important to encourage descriptive answers that reflect the participant's personal opinion to receive the richest possible data.

Before the final interview guide for this research is presented, it is necessary to confirm the proposed guide's coverage and relevance. The authors mention three different techniques to test the interview guide, "internal testing, expert assessment and field-testing". The first method was chosen for this study, and the questionnaire guide has therefore been discussed with this thesis mentor, Prof. Vitor Duarte dos Santos.

The final step is presenting a semi-structured interview guide that is being used in the context of this study. The questions asked in the interview will be provided in a later chapter.

3.4. CASE STUDY PROTOCOL

As a final step of preparation before starting to collect the data from the case study, Yin (2018) suggests creating a case study protocol. This protocol is a guide of procedures to be followed during the case study research. This kind of guidance has major advantages and is increasing the general reliability of a case study research. In addition, it helps to focus on the topic, set out a plan to overcome future obstacles, and identify and target the right audience before the actual case study is being carried out.

The case study protocol is divided into four sections, according to Yin (2018). The first section is the overview of the case study. In this section, all significant information should be covered as well as any substantial issues and further readings about it. It should familiarize the reader with the case study's purpose and the setting. The overview should be so in-depth that it may form the foundation for the propositions in the final case study report.

After establishing the case study overview, the next section should include the data collection procedures. They are necessary if there are open issues or if questions arise that go beyond the boundaries of the research. To manage those unexpected interruptions, it is required to build up a schedule that provides a structure to the research with timings for routine activities.

Thirdly, the crucial part of a case study protocol, the protocol questions. They are formulated to reflect the outline of the study and therefore keep the data collection processes in line with the initial scope. The author suggests five levels of questions initially, but only the first two levels are applicable for a single-case study. Therefore, the protocol includes only the first level, “questions verbalized to specific interviewees”, and the second level, questions asked about the individual case.

Concluding the development of a case study protocol is a tentative outline for the case study report. By providing boundaries, it improves the collection of data, hence minimizing the necessity for a redundant and recurring review of fieldwork.

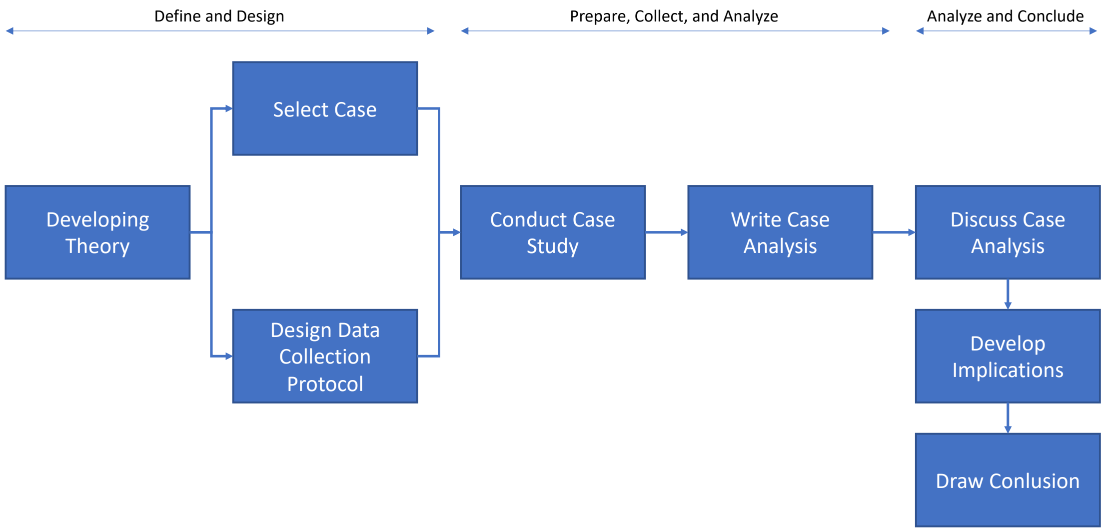

Figure 5 – Phases of this research’s case study based on Yin (2018), p. 94

With the completion of the case study protocol, this study's design and preparation stage will be concluded. The preceding Figure 5 is providing an illustration of the different phases of the case study approach by Yin (2018) adapted to this research.

4. CASE STUDY – TRADELENS

4.1. CASE SELECTION

TradeLens has been adopted by large enterprises in the maritime industry already. Therefore, it is necessary to understand how SMEs perceive blockchain and what roadblocks could arise when the implementation of the technology could be considered.

Literature suggests that SMEs do have an interest and see the perceived usefulness of blockchain. Ilbiz & Durst (2019) find in their study about the appropriation of blockchain for SMEs that the new technology does possess the ability to overcome problems that SMEs face in many industries. The cost-efficient and transparency-enabling potential of blockchain bears great opportunities, especially the alternative approach to business process management is pointed out as a possible blockchain adoption for SMEs. Nevertheless, the authors also point out that there might not be an urgent necessity to adopt this novel technology. Even though there are already SMEs that have implemented the technology, owners should not be deceived by the general hype about the usefulness of the technology. Significantly, the necessary network and the lack of standards and regulations should be subject to great attention when choosing to implement blockchain.

In another study, Bracci et al. (2021) examine the factors that lead SMEs to adopt blockchain technology. In their research, they found that the key advantages of blockchain as perceived by their respondents are cost reduction, rapid transaction, transparency, and immutability. Further, the research found that the main areas of interest for the application of blockchain are product traceability, smart contracts, IoT, and supply chain management. However, the main barrier to the adoption of the technology is the level of knowledge about it. The authors find a linear relationship between the interest in the adoption and the prior knowledge about blockchain. Further limitations are the volatility and initial costs. Due to the limited resources of SMEs, they tend to be more hesitant with the selection and implementation of new technology (Bracci et al., 2021).

Lanzini et al. (2021) analyze in their study the blockchain adoption factors for SMEs in supply chain management as they see that there is limited evidence on this perspective. They rank different factors that influence the SME to adopt blockchain to point blockchain consortia toward which elements they should focus on to provide greater usefulness. The leading factors are process readiness, people readiness, and top management support. They conclude from their findings that blockchain consortia advocate the connection between the technology and the innovative processes it enables to convince companies and their executives of the usefulness of its adoption.

The given literature provides evidence that SMEs do have a genuine interest in the implementation of technology like blockchain. The following will examine the development process of TradeLens' solution to give a greater understanding of how it is tackling challenges that are present in the maritime industry.

4.2. DEVELOPMENT OF TRADELENS

The origin and development of TradeLens followed a different approach than traditional IT projects. Instead of defining requirements and stated objectives, the final product emerged from different initiatives and many iterations consulting involved organizations and bringing up innovative solutions (Jensen et al., 2019). Three of those innovative solutions had preceded before the formal establishment of TradeLens, the Shipping Information Pipeline initiative (SIP), the Paperless Trade (PT) initiative, and the Global Trade Digitization (GTD) initiative, combining the first two (Jensen et al., 2019).

The first SIP initiative was part of Maersk's digitization strategy and efforts to develop a solution to facilitate the information exchange in the global supply chain between their participants from 2014 to 2016. The final prototype was developed with the support and insight from governmental agencies, shippers, freight forwarders, and other participants. Providing a framework for information exchange through connectivity and infrastructure, the focus was on setting a standard for the exchange rather than what the actual information should be. Blockchain was not considered at that stage since it was too novel at the time being. The proposed SIP prototype was well received by the executive board of Maersk, and funding for the next development stage was made available. Even though one demand was made, the SIP should be aligned with another initiative, the Paperless Trade initiative (Jensen et al., 2019).

At the beginning of the joint efforts of Maersk and IBM to evaluate the possible opportunities blockchain technology might bear for the shipping company, they focused on the digitization of trade finance. However, due to regulatory restrictions, Maersk executives abandoned this approach and narrowed the scope of the initiative to supply chain solutions. This became known as the PT initiative, and after some iterations, the development team came up with a blockchain network that enabled the transfer of encrypted trade documents (Jensen et al., 2019).

These two initiatives were then combined in a joint effort under the Global Trade Digitization initiative (Lal & Johnson, 2018). In line with the initiative's effort, five major trade documents had been chosen, each one of which was required stamped and signed by importing and exporting authorities. Therefore, the documents' uniqueness and authenticity were identified as critical factors for the following prototypes. Table 1 shows the chosen documents and gives a short description. Further, with the increasing efforts of the initiative, blockchain seemed to be a promising technology to be used for this specific case of trusted information exchange (Jensen et al., 2019).

Document	Description
Bill of Lading (B/L)	A legal document between a shipper and a carrier that details the type, quantity, origin, and destination of the goods being carried
Packing list	A list of the goods being shipped in a container
Certificate of origin	A document issued by the authorities in the country of origin verifying the shipment’s origin and content
Commercial invoice	Document required by customs to determine the value of the imported goods for the assessment of duties and taxes
Export certificate	A government document granting the licensee the right to export a specific quantity of goods to a specified country

Table 1 – The five key shipping documents selected for the blockchain-based prototype and pilots (Jensen et al. (2019), p. 230)

Although the development process of a pilot proved to be difficult, mainly due to geographical separation between the Maersk development team, based in Denmark, and the IBM research team in the US with sub-teams in India, the first of the prototypes was tested on a shipment of cut roses from Kenya to Europe in late 2016 (Jensen et al., 2019). After some more iterations and pilot testings, the solution was further enhanced in 2017 so that it could be commercialized for the whole market. In 2018 the joint-venture, TradeLens, was founded as its own company, with Maersk owning 51% of the company and IBM the remaining 49%. TradeLens positioned itself as an open and distributed platform, independent from Maersk even though them owning the majority of the company (Lal & Johnson, 2018). The underpinned blockchain technology allows, in the TradeLens ecosystem, permissioned sharing of information and documents through application programming interfaces (API). The access control structure of the platform ensures that the transactions are encrypted, secured, authenticated, and verified. In addition, the platform supports the use of smart contracts enabling automated self-execution upon specified events.

The chapter on blockchain in the shipping industry, chapter 2.3., has already assessed the issues and challenges that are driving the maritime industry to be digitized. Jensen et al. (2019) identify four key challenges hindering the industry from a leap forward into the age of digitization. Those challenges are the lack of a uniform IT system for all supply chain participants, no standardized infrastructure for trade documents, the multitude of documentation that needs to be updated by multiple participants, and many regulations that impose the use of paper-based documentation. Those challenges have a major impact on the supply chain and its partners. The author highlights that $257 billion in annual administrative costs, or 22% of the retail price of the transported goods, can be traced back to the processing of documents, as estimated by United Nations ESCAP (2014) in their annual report. In addition to the administrative costs, the arrival time of ships and the high uncertainty coming with it are also creating ripple effects in the supply chain. The arrival time is often not known until three or four days before the ship arrives in its destination port due to a lack of information sharing between authorities, carriers, terminal operators, and others. Adding to this the high amount of delay, ships are usually late for days and not for hours; three out of ten ships are late by more than a day resulting in even higher uncertainty. The final issue highlighted by Jensen et al. (2019) is the supply chain delays caused by monitoring schemes and frameworks of the participants of the supply chain due to security risks. The relationship between those challenges and their causes is illustrated in Figure 6.

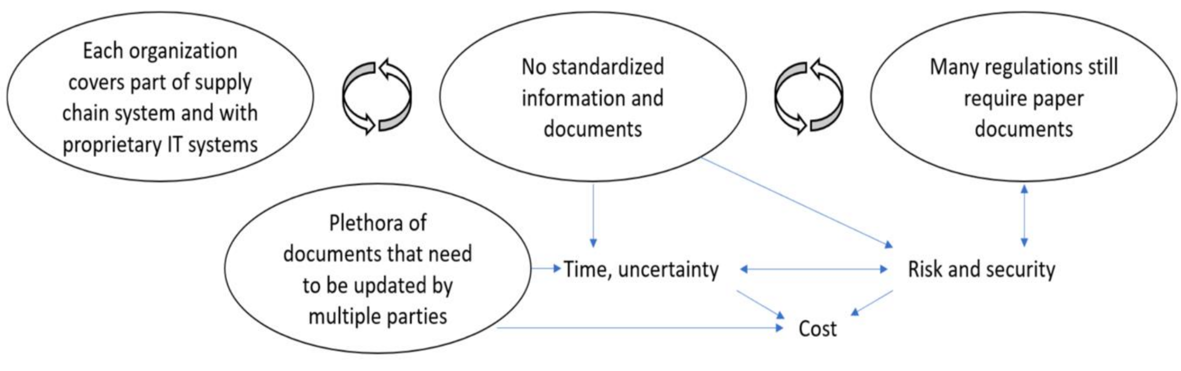

Figure 6 – Four causes of the challenges faced by global supply chains (Jensen et al. (2019), p.223)

Another challenge addressed by Milian et al. (2019) is that the blockchain implementation's success depends on the information sharing and the handling of trust issues of the participants. Therefore, legislative regulations, as well as issues concerning cybersecurity, should be two significant factors for the successful implementation of the maritime blockchain.

4.3. CASE IDENTIFICATION

When TradeLens was first introduced, the solution had many iterations to improve its services and offers. The solution is now composed of the ecosystem, which includes the participants, like carriers, authorities, port terminals, amongst others, that are connecting to, sharing data with, and using the platform. The platform connects the ecosystem through a set of open standards. The platform can be accessed through an open API, and it enables the industry to exchange information and collaborate. Blockchain and cloud technologies power the platform. The final part of the landscape is the marketplace that sits on top of the platform, enabling TradeLens and third parties to offer their individual services to the participants.

The platform uses a cloud-native approach. The functionality of TradeLens is ensured through the API, which is public-facing and well documented.

The blockchain network of TradeLens is based on the Hyperledger Fabric. Hyperledger is an open-source permissioned blockchain network that is supporting to set the standard for blockchain frameworks and platforms (Laurence, 2019). It is known to provide the basis for blockchain solutions that meet the needs of business enterprises that are deterred from using the technology due to its set of regulatory restrictions. The Hyperledger Fabric is used for ledger and smart contracts. The blockchain topology of TradeLens is built in such a way that the separation of the participants, which may be competitors, is ensured. Mainly TradeLens and maritime shippers are hosting and managing the nodes. Each node contains the components of the blockchain platform and dedicated blockchain-managed storage for each specific node. For every participating maritime shipper, a channel is established. Appendix E illustrates the TradeLens Permissioning Matrix. A Hyperledger channel is a private sub-ledger that can be used for communication between specific participants whose transactions need to be confidential and private. Confidential information, including documents, is only distributed to nodes participating in a channel, which means that no customer information from one shipping company is shared with others. Documents are only stored on a single node and are accessed at runtime by other nodes in a channel if they are authorized. Secured access control ensures that only organizations that have the permission can access information. Appendix B shows the blockchain network component in detail.

4.4. CASE INFORMATION RETRIEVING

The information retrieved throughout the course of the case analysis comes from different data resources. The main source is the information provided by the official TradeLens website, including their “Knowledge Hub”, their documentation and White Paper, and the blog. There the architecture, operations, information regarding their products, and the ecosystem are being provided. Additionally, the latest version of the TradeLens whitepaper will be examined. Further, the article by Jensen et al. (2019) is also taken into account regarding the business value TradeLens is offering. Finally, after the case, discussion interviews have been conducted with strategic decision-makers of maritime SMEs to verify the case study's findings and discuss possible challenges.

4.5. CASE ANALYSIS

In the following chapter, the mentioned challenges the shipping industry is facing are being revisited and set into context with the TradeLens platform and the solution it is offering to those.

4.5.1. SHIPMENT EXAMPLE PROVIDED BY TRADELENS

In previous chapters, the architecture of TradeLens has been analyzed, the relationship between nodes and the Hyperledger channels has been established, and the data-sharing capabilities of the blockchain solution have been explained. To fully grasp the technology's features, understand how they are all connected, and understand how this solution would be beneficial for their end-users, SMEs in this case, the shipment process with the support of TradeLens will be examined in the following. To do so, the official "TradeLens blockchain technology supply chain demo" video was screened and analyzed.

The shipment follows 480 LED-Televisions from inland China, Zhengzhou, to their final destination on the West Coast of the US in Long Beach, CA. First, the shipper submits the shipping instructions to the carrier using the document sharing capabilities of TradeLens. The carrier then accesses the information and drafts a Bill of Lading (B/L) the shipper then must review. The B/L is then being verified by the shipper and the carrier. The verified B/L is then made accessible by TradeLens for other participants of the shipment process, i.e., the customs broker, the port authorities of the entry port, and the cargo owner at the final destination. Throughout the travels of the shipment, different documents are necessary for it to pass on to the next stage. For example, a commercial invoice is required by customs to determine the value of the shipped goods to assess the duties and taxes for import. TradeLens' permissioning-model manages the documents and information regarding the status of the shipment. It controls who can add, view or update information or documents at every stage of the shipment, also including blockchain-encrypted audit trails for every critical action to ensure the validity of the information. When coming back to the shipment of the LED-TVs, the shipper requests to divert the shipment, due to a shift in inventory, for example, to a different distribution center in the eastern US, Savannah, GA. Following the requested change, the container with the shipment must be discharged in Busan and booked on a second vessel traveling to the new destination.

Usually, this would cause a great effort: the shipment must be rebooked, new B/L needs to be issued, and changing the manifest, sending each via courier to the right participants, causing delays in the shipping process.

TradeLens enables the carrier to create and share the adjusted B/L on the platform and the permissioned parties. Further, the customs broker gets updated with the new information from the platform can adjust the shipment's import declaration to submit it on time to the US customs. Any permissioned party can access the status of the shipment through a variety of parameters on the platform. The status is shown in the transport plan, which displays key milestones and events along the timeline of the shipment. Over 120 planned, estimated, or actual events are supported by TradeLens, that are being tracked in real-time. Providing detailed insights along the supply chain. In the case of the example shipment, the supply chain participants downstream are notified immediately about the change. The port authorities, terminal operators, inland transporters, and consignees then can tightly coordinate necessary actions to allow near-instant logistical adjustment minimizing the disruption.

4.5.2. DATA SHARING WITH TRADELENS

Blockchain-enabled data and document sharing are some of the key features of TradeLens. Milian et al. (2019) explain that the measures and frameworks need to be introduced to enable trust in the technology and ultimately guarantee its successful implementation. Those features are security, the data-sharing model, and standards and interoperability promoted by TradeLens.

Security

Cybersecurity is one of the major concerns when digitizing business operations. The worry of moving one’s own and customer's proprietary information to a new digital platform and exposing it due to a lack of preventive security standards. TradeLens is using the permissioned blockchain based on Hyperledger Fabric. This is not only ensuring the immutability and traceability of the trade documents but is also protecting the data with advanced encryption technology (Biazetti, 2019). Further, the platform is built on Z/System and Linux ONE security to prevent ransomware from locking the data. The permissioned blockchain also protects the external entry because every user and even every organization has encrypted certificates. Mainly the choice for a permissioned blockchain should be highlighted. Members can only access it if they get the permission. The level of access is specified as well as their level of control. This invite-only network approach, where companies have been thoroughly checked before they can enter the network, as well as the management and monitoring of the users through the Permission Matrix, ensures trust among the participants. Particularly the participation of IBM in the development of the solution ensures the security of the platform. TradeLens is using comprehensive security that IBM is also managing for Furtune500 companies. Meaning the set of security standards, robustness and scalability are equal to those used by some of the world’s largest enterprises (Biazetti, 2019). This includes security development processes from IBM like, source-code reviews, industry-standard encryption algorithms, and vulnerability management. TradeLens is not only meeting the already stringent GDPR requirements necessary for data handling in the EU but already higher standards mandated by any authority. TradeLens, therefore, is accredited with the ISO27K certificate, a set of standards for information security, issued by the International Organization for Standardization and the International Electrotechnical Commission.

Data Sharing Model

To ensure trust in the platform from its users, TradeLens set of general key principles for data sharing (TradeLens, 2020b). Those include that no data is shared with any party unless they are part of the TradeLens network. Only network members or customers that have been accepted by TradeLens have agreed to the Terms and conditions and have been onboarded. TradeLens is enforcing strict access control on the permissions the participants have on different information regarding shipments and consignments. The data-sharing model of TradeLens recognizes the various complex relationships between the different logistical and commercial parties. Specifically, for shipments that comprise a multitude of consignments that are contracted to different parties, which then further subcontract the transport of a shipment receive access to different information and documents according to their role and access.

As a response to the concern about the self-organized ecosystem that is handling data of maritime and global supply chain participants, transparent and strict rules for data sharing must be enforced. Access permission management and data provisioning requirements are therefore deeply integrated into the TradeLens architecture. Documents that are uploaded to the platform are first categorized automatically by their type, in line with UN Centre for Trade Facilitation and Electronic Business (UN/CEFACT) standards. The three types are shipment, consignment, and transport equipment.

The first one is associated with goods that are being transported from the seller to the buyer. This includes the shipping arrangements and the movement of products, including dispatch and delivery, despite the mode of transport or the contracting and subcontracting relationships. Documents that are categorized as consignments are related to the transportation of goods from one consignor to one consignee. Including the mode of transport, one or more, that is appointed in a single transportation contract. Transport equipment is the physical equipment to hold, protect, or secure the cargo in the logistics process. Some transport equipment is being re-used and are therefore further constrained. Each instance of usage of an equipment is therefore noted separately, in the context of either a shipment or a batch of consignments moving end-to-end of the transportation. Figure 7 conceptualizes the hierarchy between the three different types and how they are related to transportation.

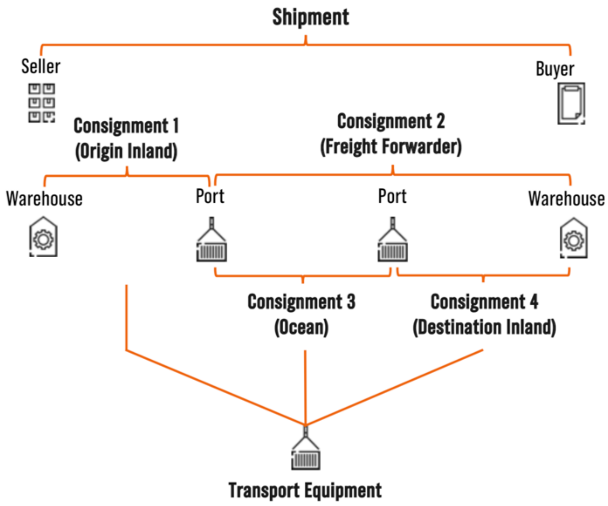

Figure 7 – Example Hierarchy (TradeLens (2020b), p.6)

A bill of lading, for example, relates to the consignment, while a commercial invoice relates to a shipment. Further, the documents are issued by different participants of the supply chain, depending on the type. For example, the shipper is uploading trade documents, and the carrier is uploading transportation documents.

Throughout the course of a shipment being transported, updated versions of documents are being issued. Therefore, TradeLens is providing a versioning system. The documents are being uploaded as either structured JavaScript Object Notation or unstructured PDF or JPG documents. The document is saved on a secured datastore on the blockchain node but not on the ledger itself. Instead, a hash (Hash A) of the document is connected to the ledger. This is where TradeLens' blockchain application ensures the immutability and traceability of the information provided. When the document is retrieved, Hash A is compared with a new hash (Hash B) generated for the retrieved document. Only if the hashes match is the document considered verified. Each time a document is edited or uploaded, a new version of the document is created and added to the solution to prevent errors during verification. This ensures a structured version control of the published documents. Appendix C illustrates the process of TradeLens document versioning.

When the document is uploaded, the participants can access it, following the permission matrix. The permission matrix precisely specifies which participant can access which document and with whom he can share it.

Standards and Interoperability

The lack of standards for documentation and the necessity for interoperability between platforms are still drawbacks in the industry. TradeLens works closely with the Industry Advisory Board, participants in the ecosystem, and standards bodies to promote the consistent use of widely used codes and data models across the industry. The data model and access control scheme in TradeLens is aligned with the UN Centre for Trade Facilitation and Electronic Business (UN/CEFACT) model. To tackle the missing industry standards for data exchange, TradeLens is promoting openness, with all functionalities delivered via non-proprietary, publicly available APIs specifically designed for ease of use and integration. TradeLens also offers increasingly standard integrations with ERP, TOS, TMS, and WMS packages. Finally, TradeLens also facilitates the interoperability between blockchains, following standards that are evolving in the industry for blockchain use, which would also include cross-ledger namespace and transferring information between different ledgers.

4.6. CASE DISCUSSION

TradeLens is today the biggest global data-sharing platform in the maritime industry (Louw-Reimer et al., 2021). The success of the company and its blockchain solution already had an advantage due to its nature, being the joint venture of two large enterprises, each of which has been a major player in their respective industries. Despite that, TradeLens is offering an innovative yet novel solution to the maritime ecosystem and is therefore still developing and improving. From the early collaboration between Maersk and IBM and the early initiatives, over prototypes and version testing to the final product was developed over a series of iterations. In June 2021, TradeLens announced that Hapag-Lloyd, the biggest German shipping company, and ONE, Japan's biggest shipping company, were joining the network. At this stage, the platform had already processed over 42 million shipments, 2.2 billion events, and more than 20 million documents (TradeLens, 2021a). Those numbers increased by nearly 50% till today (Feb. 2022), as seen on the platform activity indicator on the TradeLens website (TradeLens, 2022). As discussed throughout this research, the potential of the blockchain solution is massive. Not only the already mentioned benefits of digitizing trade documents and facilitating data exchange, but it also bears the opportunity for digitalization of the whole supply chain processes. The latest addition to TradeLens network, the successful completion of a letter of credit transaction with HSBC, one of the world’s largest bank and financial service providers, and Syngenta, a leading agricultural science and technology provider, using the eBL through blockchain technology (TradeLens, 2022). This marks a milestone in the digitization of trade finance and a further increase in supply chain efficiency. Syngenta estimated that the use of TradeLens for a shipment from South Korea to Bangladesh saved ten days of lead time for document processing. This proves even further that TradeLens is providing greater efficiency than traditional paper-based document sharing processes that have been at hand.

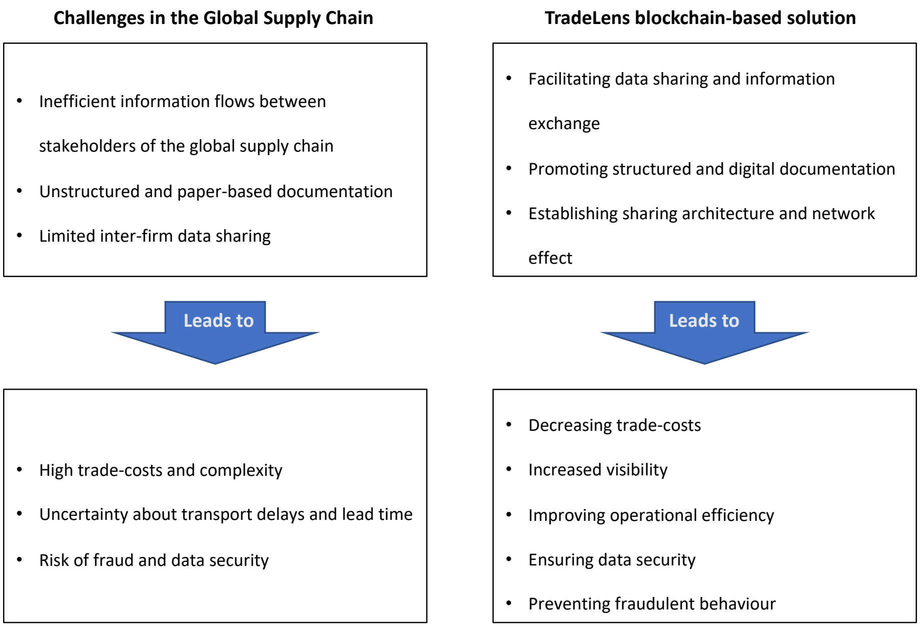

Figure 8 – Challenges and the solutions provided by TradeLens (based on Jensen et al. (2019), Jensen et al. (2018), and Jensen and Vatrapu (2015))

Together with the fact that it is the leading provider of digital data sharing, it is a fitting case study for SMEs in the maritime industry. Figure 8 conceptualizes the challenges and the solutions TradeLens is providing. Even though implications from the case will be drawn in the following chapter, it is necessary to assess possible challenges and limitations TradeLens is facing due to its novelty.

TradeLens has attracted many large enterprises, namely five of the six largest ocean carriers, major terminal operators, customs authorities, and others. The blockchain-based solution has sparked the interest of many participants in the maritime industry, but still, the general adoption is progressing slowly. Jensen et al. (2019) have identified two interrelated causes responsible for the hesitation. First, the general reluctance of investing in technology infrastructure, that is, enabling the use of blockchain platforms before there is an ecosystem to connect to, is holding back the commercialization of TradeLens. The addition of new members is increasing the value of the platform, but without members, the value of the network cannot be fully unfolded. The initial IT investments necessary to join TradeLens are therefore discouraging potential participants. This is indeed a well-known problem that communication technology and innovative networks are facing. They will not gain value if a critical mass does not adopt it. The second cause for slow adoption the authors mention in their article is the hesitancy to share sensitive trade documents with a blockchain solution and trusting this technology that these will remain secure. Although blockchain should ensure potential participants the security of their data, the competitive nature of the maritime industry is making stakeholders inherently skeptical of a data-sharing solution that is being suggested by a rival to share sensitive data.

Additionally, users who are working for government authorities might believe that the introduction of smart contracts and the embedding automatization of verification processes make their jobs obsolete and are therefore reluctant to change. Lastly, governmental restrictions are blocking the use of TradeLens, in terms of handling digital documents. For example, the EU Regulation 1960/11, Article 6 states the requirement of two original documents with stamps (EU Regulation 1960/11, Article 6). Like Canada, Russia, Saudi Arabia, and Singapore, some national governments have signed up with TradeLens. However, the regulations of other countries prohibit the use of TradeLens. This proves to be a vicious cycle where most enterprises in the industry accepting blockchain-based solutions could put pressure on governments to pave the way and join them, but the governmental restrictions hold those enterprises back from making an investment and committing to the technology. Again, an extraordinary network effect could occur if a critical mass of participants would join.

In their case study, Louw-Reimer et al. (2021) discuss future challenges a digital platform like TradeLens needs to overcome to achieve its full potential. The first one discussed is the ownership and disclosure of the shared data. TradeLens will reap its absolute value when all the data that is relevant for the shipment of goods can be made available on the platform. The availability of data on the TradeLens platform shows a substantial divergence between consignment-related data and shipment-related data. About 99% of the consignment data is available in a digital form, allowing complete automated processes for the creation and processing of the transport data. Customs documents, for import and export, Cargo Manifest procedures, Entry Summary Declarations manifests, or Arrival Notifications can be automatically generated through TradeLens by the data that has been made available. The availability of shipment data is another case since the availability depends on the involvement of the buyer and seller. If the shipper is not directly engaging with the carriers for the transportation and is instead using an intermediary, like a third-party logistics provider (3PL), the 3PL needs to provide the data. The 3PL sees TradeLens more like a competitor than a partner and is, therefore, more resistant to share the data of the shipment.

Another challenge addressed by Louw-Reimer et al. (2021) is less of a technical nature but more business-related. The literature chapter already explained the complexity of the maritime industry as well as other initiatives concerning blockchain in the shipping industry. Indeed, there are businesses in the maritime industry that are already collecting and selling information, and those already existing platforms could feel threatened by TradeLens. For example, port communication systems (PCS), which sole purpose is providing transparency, data sharing, and generally process improvement, by providing port data could be one of those businesses. Even though they would like to share location-specific data and receive, on the other hand, general data from TradeLens, their idea of the blockchain solution is to make data generally available, making the PCS see TradeLens ultimately as a competitor. This will put pressure on the port authorities to choose between competitors offering different data quality. This increased pressure from the introduction of TradeLens will also be affected further businesses in the maritime industry. Customs brokers, for example, also need to adapt since their business model includes the supervision and certification of trade lanes and the necessary documents for transportation on these. TradeLens is making those intermediaries obsolete by facilitating data exchange and making it more accessible.

Finally, Louw-Reimer et al. (2021) address a challenge to a more geopolitical extent. TradeLens is offering a platform that is an open system with broad global coverage. But there are countries or even regions which favor their own local or global network, running their own technical solutions, encryption methods, or governance frameworks. HMM's mentioned "New-GAUS 2020" is more internally focused, COSCO's GSBN is a more direct competitor to TradeLens with a strong focus on Asia but with the vision to tackle the global market. Both TradeLens and GSBN have great names to their portfolio of members, with a few even using even both solutions. In an interview, Michael White, director of TradeLens, is talking about the interoperability of TradeLens, and suggest that in the near future logistic platform must find a consensus on data exchange and standards since this is the general premise of TradeLens' business model (Johnson, 2019).

Having the TradeLens solution thoroughly analyzed in their technological features and solutions that it is offering to the mentioned challenges in the maritime industry, providing visibility and transparency in the data exchange, advocation documentation standards, increasing the security of the traditional processes, and providing better assessment, the following chapter will now formulate implications for SMEs in the given environment.

5. IMPLICATIONS

After the case of TradeLens has been analyzed and discussed, where the benefits of the implementation of a blockchain solution have been pointed out as well as the challenges the chosen case might face, implications will be formulated. To validate any implication drawn from the case of TradeLens, interviews have been conducted, with participants in the maritime industry, to gather opinions and insights, which will be added into this analysis. The participants were chosen based on their role as strategic decision-makers in maritime SMEs.

After an introduction of the topic and objective of the study, three main questions have been formulated for the interview, with follow-up questions addressing specific issues of the study for the interviewees to answer, sharing personal opinions and professional experiences.

The Questions are the following

1. - What are the biggest challenges SMEs are facing in the maritime industry?
    - 1.1 - If not mentioned already, do you see the physical document exchange, the lack of documentation standard, and the missing transparency in information exchange as an inefficiency?
2. - Do you believe that the implementation of a digital data-sharing platform could be beneficial for SMEs in the maritime industry?
3. - Do you consider the blockchain solution of TradeLens would be a good option?
    - 3.1 - If not, why, and what would TradeLens have to change for you to be confident about it?
    - 3.2 - If yes, do you plan to implement such a solution?

5.1. INTERVIEWS

Regarding question 1

Interviewee 1 (I1):

There are two issues that need to be addressed: One is climate change, and the other is digitalization.

As far as the issue of climate change is concerned and the expectation that our industry will find answers in the very short term as to how emissions can be reduced, that is a huge challenge that ultimately also really rests with the individual entrepreneur. Politically, the framework conditions are in place, but everyone must think about how to implement this in the market as a whole, which still does not necessarily reward first-movers.

In addition, there is certainly still a lack of infrastructure in the logistics and supply chain sector as far as digitalization is concerned. This means the classic idea of what can be done around blockchain to exchange documents. To generate security across the entire value chain and to strengthen automated processes. This is a topic that many small and medium-sized enterprises still do not really have on their minds. There is still a lot of manual work, a lot of telephoning, a lot of paperwork. In every respect, you are one small cog of many, and that makes it very difficult to do a "track and trace" that both ticks the legal boxes, i.e., how the legal requirements are covered in some form in various jurisdictions, and also raises efficiencies, optimizes commercially and sets things up for the future.

Interviewee 2 (I2):

The Ukraine crisis. It's an immense issue in every respect. I mean from the commercial side to Crewing. Or rather, those two are the most affected. Otherwise, of course, there are still two overriding issues, decarbonization and, of course, at some point, the whole digitalization of the value chain.

It is the entire value chain. Especially where transport plays a central role, so to speak. The flow of information is not given or only given to a very limited extent. If you look through the glasses of the special goods that are transported, it is still a less transparent process with high administrative costs. With a simple container transport from China to Europe, you have a lot of administrative hurdles if you want to transport this container. So, there is little information flow as far as that is concerned.

And especially in the area of container shipping, the aspect of security plays a big role. Because of the lack of transparency, there is always a lack of safety on the ships. For example, the fire accident of the MSC Flaminia, which burnt out on the North Atlantic at the time, due to false declaration and other information about the cargo. And of course, this is also due to a lack of transparency in the value chain. When the producers of goods try to save money by declaring the cargo differently, that can go well or poorly.

Regarding question 2

I1:

That is a double-edged sword. Of course, the service provider chain is also very long because the processes are inefficient. This means that there are certain companies in the value chain from the owner of the cargo to the consignee now that also live off the fact that there are inefficient processes. They fill out documents manually, which is much more labor-intensive to ensure that the process is forgery-proof and reliable. This means that there are certainly losers in this context. It is not the case for every company that they can adapt this, that their business model only needs to be adapted, but that it is replaced.

The idea of blockchain or communication that is fully automated and transparent for all stakeholders is ultimately also one that directly connects the end customer with the shipper or the person who sends the cargo and does not make five middlemen necessary. Or somehow lost in translation, one or the other does not arrive at the consignee's at all, and everyone holds out their hand once. This means that you may have a clear added value for a shipping company because the position of the shipowner who makes his ship available is strengthened, and he is no longer dependent on any operators, agents, charterers, or anything else.

Instead, he can communicate relatively directly with the end customer and offer his service to the end customer. So, it's a mixed picture: not better for everyone. Digitalization as such is always a very generically chosen term, but of course, it also replaces existing job descriptions, and that will not be advantageous for everyone.

I2:

As a small company, it is, of course, important in which areas you operate. Especially in container shipping, this is a great benefit. In the tanker and bulk carrier sector, perhaps less so here. Simply because you have a single parcel and then also a port of discharge, but it is also an issue there in terms of documentation, tracking, and so on. But of course, it's much less because you simply have fewer stakeholders. With a container ship, there are sometimes a thousand boxes on board, which all have to go to different ports, and the bulk carrier only calls at two ports. So, I would distinguish here between the segments in shipping.

Regarding question 3

I1:

I think as a shipping company it can be very interesting. As a shipping company, you are probably not the first mover, but the end customers whose goods you transport. They must have an interest in this being fully transparent, so to speak. They drive it, they say in case of doubt, my transport will be more expensive if I have so many middlemen. In addition, I don't have the process under control. I'm not completely up to date on the entire supply chain, where what happens and how, I want to have traceability, etc. That is, I think it's an advantage for me to be able to have a transparent supply chain.

I think the advantage on the shipowner side is secondary. Not secondary in the sense of less important, but secondary in that the shipowner is not necessarily the driver and says, okay, I'll do it. Because the charterers and operators, i.e., the classic direct customers of the shipowner, are not necessarily interested in a vision that TradeLens presents in its entirety becoming fully established. They are afraid of becoming obsolete themselves. Accordingly, here again, a mixed answer: it is, of course, in the shipowners' interest to get a more direct line to the end customers and to understand their needs to develop new ships for them, if necessary, to reduce dependencies, etc. And this could be possible via such a model. And this could be possible through such a model because you don't need such a long chain of intermediaries to design clean processes.

After explaining that five of the biggest shipping companies have introduced TradeLens, I further asked I1 why he hasn’t considered implementing blockchain:

Well, you know how it is. So, when you talk about the biggest five, these are fully integrated shipping companies that are also operators. So, they aren't tramp shipping companies. That means that it is an incredibly heterogeneous field of companies in the shipping environment. Sure, if you look at Hapag-Lloyd and Maersk, they have their fleet, but they also have a chartering department, they have direct access to the freight forwarder, and they often have direct access to the end customer. This is a totally mixed portfolio, and it makes a lot of sense to introduce a structure that allows a standardized process to be applied across these different stakeholders. But if I am a tramp owner sitting on the asset and has no direct connection to the cargo, usually, but only put the ship out to Time Charter, who then say okay, now I'll do a voyage charter with a shipper, who is not necessarily the end customer. Then you have a much longer chain that does not immediately guarantee added value for the tramp owner because he can only be interested in it if he questions the previously established partner structure with a time charterer.

So, in the medium term, the tramp owner wants to be fully integrated, wants to do the cargo directly, and wants to do commercial management. So, for the classic asset manager, it is what I said earlier, from my point of view: you are not a first-mover because basically the immediate added value is not there immediately, commercially. If you have a fully integrated company and already map the value chain in the broadest sense under your roof or at least accompany it very intensively, then it makes sense to take a closer look at TradeLens or competitor products at an early stage.

5.2. Discussion

In this part, the insights provided by the interviews will be connected to the findings from the case analysis of TradeLens. First, it will be discussed if the challenges of SMEs in the maritime industry match the ones that are generally associated with the industry as a whole. Second, the general usefulness and the benefits a blockchain solution could offer will be analyzed. And finally, if the blockchain platform that TradeLens is offering will also be feasible for SMEs.

For the first part, the interviewees generally agreed upon the challenges that need to be tackled in the maritime industry for SMEs.

Climate change as a global and industry-overarching megatrend is a challenge that needs to be overcome by everyone. Also, current events like the invasion of Russia in Ukraine have direct effects on the global economy and, therefore, on the shipping industry as well. But another trend mentioned is the general need for digitization. It is necessary to digitize the paper-based processes and streamline the document exchange while ensuring security along the value chain. This is aligned with the challenges TradeLens is mentioning that it wants to tackle. The main purpose of TradeLens is to facilitate document and information exchange throughout the supply chain.

The second part of the analysis discusses the benefits of the implementation of a data-sharing platform. Especially the container industry was mentioned by I2 as eligible for the implementation of a data-sharing platform due to the business model and the operations that inherent this mode of transportation. However, while there is an interest in ship owners and shipping companies to facilitate direct contact with the end customer, the introduction of a data-sharing platform has different effects on other businesses along the maritime supply chain. Especially, as I1 mentioned, the businesses that have built their business model around the inefficiencies the industry is subject to will become obsolete through the introduction of such technology. Therefore, the widespread introduction of it will meet resistance.

The final analysis part addresses the actual implementation of TradeLens in shipping SMEs. While the interviews gave great insight into the interest in implementing the solution offered by TradeLens, one could see that SMEs are especially dependent on their customers' implementation. The big shipping enterprises like Hapag-Lloyd and Maersk, which are already customers of TradeLens, are fully integrated companies. Meaning they are not taking care of a single part of the maritime supply chain but have either subsidiaries that are facilitating the pre-and post-shipping processes or doing those themselves. Therefore, it is easier to integrate such data-sharing platforms into their business model.

Summing up the discussion of the interviews and the findings of the case study, TradeLens could offer great benefits to SMEs in the maritime industry. On the one hand, TradeLens is offering operational improvements by reducing paper-based documentation and streamlining the information flows in the maritime industry. Further, security is ensured throughout the documentation. The platform is promoting standards for documentation, which results in less fraudulent and error-prone behavior. Concerns about the data security of the shared information are not only dismissed using blockchain technology, but also the permissioning model supports the controlled sharing between the various parties that are operating along the global supply chain. While the fully integrated large enterprises have already made a step ahead by implementing the TradeLens blockchain solution SMEs are still dependent as a second-mover on the implementation decision of their customers and other stakeholders. This will likely be overcome with a general industry-wide adaptation of blockchain-based data-sharing platforms. As five of the six largest ocean carriers that use the TradeLens solution make up to over two-thirds of the container shipping market, it will only be a matter of time until an industry-wide adoption (Statistisches Bundesamt, 2022). Further, the interviewees mentioned some genuine interest after the TradeLens had been proposed to them.

The earlier case discussion, in Chapter 4.6., also mentioned the challenges TradeLens and other blockchain-based data-sharing platforms could face. These have been validated as well by the interviewees, especially in terms of resistance from stakeholders, who are dependent on the inefficiencies along the global supply chain.

Reverting to the research questions to understand the why and how of blockchain implementation for maritime SMEs, the case analysis gives great insight. From the challenges identified and the validation through the interviews, the general need for digitization in the maritime industry is a key point for SMEs as well. The solution TradeLens is offering is tackling the lack of information flows and documentation structure and is providing the participants with a framework for data sharing. This results in increased operational efficiency, transparency throughout the global supply chain, and reduced costs.

6. CONCLUSION

6.1. SYNTHESIS OF THE DEVELOPED RESEARCH

The successful deployment and industry-wide implementation of an enterprise blockchain solution depend on the collaboration between various actors in the industry (Mattke et al., 2019; Zavolokina et al., 2020) due to the nature of the technology with its multi-stakeholder network (Glaser, 2017). Also, it is challenging to overcome inherent trust issues between the users of such a solution to contribute to an information-sharing infrastructure also used by rivals.

Concluding the research for this thesis and the implications drawn from the analysis of the chosen case of TradeLens for implementing blockchain in the maritime industry for SMEs, the initial research questions have been studied and answered.

First, the environment the research is taking place in was assessed. Explaining the maritime industry with its complex network of different stakeholders and many processes, laying a foundation of the technology at hand, and discussing its challenges. Finally, the implementation efforts of blockchain in the maritime industry itself and the solution this new technology offers to the problems at hand were addressed. From this, the case of TradeLens was chosen as the most prominent example of the introduction of blockchain in shipping. The choice of the research methodology was based on the nature of the research question, being "why" and "how" questions. "Why" SMEs should consider the implementation of blockchain technology as a solution to the challenges of the paper-based documentation and the lack of information flow standards, as well as "how" would the adoption of the blockchain solution impact the information flows in the maritime ecosystem. Synthesizing from this type of research questions, a case study approach was the most suitable methodology to assess, analyze, and discuss implications drawn from this case.

In the case analysis chapter, TradeLens was thoroughly analyzed, where the development of the technology solution was assessed, the architecture was reviewed, and the functionalities were shown and depicted through an example of a shipment. Understanding the blockchain-based solution at its core helps to identify how TradeLens could offer a solution to the challenges that have been identified in the literature review. As the benefits of TradeLens have been identified, interviews with industry experts strategic decision-makers in maritime SMEs have been conducted to discuss and validate the challenges and benefits of TradeLens for SMEs. The interviews gave insight that one of the significant challenges for not only SMEs but also the maritime industry is to push for digitization. Specifically, the necessity for a digital solution was pointed out in terms of information flow and documentation. The solution TradeLens is offering was in general well-conceived but with some reservations in terms of the adaptation as a first-mover and the dependency on the customer's implementation decision as a non-fully integrated SME.

Summing up, even though TradeLens offers a great solution to pressing challenges of the maritime industry in general and SMEs could benefit from its adaptation to improve their operational efficiency, the solution still needs to address other stakeholders in the global supply chain to gain acceptance of smaller companies.

6.2. LIMITATIONS

The theoretical nature of the chosen methodology bears the first limitation of this research. Case-based research has the potential to be subject to researcher-induced bias throughout the data collection and the analysis (Grafton & Mundy, 2017). As mentioned in the methodology chapter, the statistical generalizability is very restricted in the case study approach (Yin, 2018), and therefore, the study does not aim to fully explain every possible aspect of the shipping industry and its stakeholders. Even though practical implications from the case have been drawn and the suggestive actions and investments have been brought forward, they might be subject to missing development of practical application of TradeLens in the given context and the respective significant testing methodology.

Another limitation is the sample group of interviewees. Even though all of them are experts in the chosen field and context, with enough expertise to judge the current situation as well as they have an overview of the industry, they still might be biased to their personal view and therefore, due to the tiny number of experts used to discuss the implication might be biased too.

6.3. FUTURE WORKS

Despite the limitations of this study, the implications drawn from this case with the combination of the interviews with industry experts not only built a theoretical framework for the implementation of blockchain in SMEs in the maritime industry but also arose some genuine interest in the topic by the questioned interviewees. While the interviewees have heard of the TradeLens blockchain solution and its general purpose, they have not considered its implementation due to the lack of specific knowledge about TradeLens and blockchain applications for the maritime industry. Especially when mentioning the benefits of the solution to the digitization challenge in the industry, the interviewees expressed their interest in TradeLens.

Therefore, future works could dive into two different directions. First, since the number of interviewees was small and insignificant, a questionnaire could be carried out to a greater sample of strategic decision-makers in maritime SMEs. This would help to understand if the interest expressed by the interviewed subjects could be generalized to the industries subgroup. Further, practical implementation in a maritime SME of the proposed solution with field research testing could analyze if the proposed benefits are practical.

Due to the novelty of this blockchain-based platform, TradeLens is continuously evolving and is already disrupting the landscape of the maritime industry. It will likely change the way of data and information exchange and the global supply chain collaboration. Furthermore, the proliferation of this platform and its competitors will open several opportunities for further research in different fields, like asset management, operations, and the industry's economics.

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APPENDICES

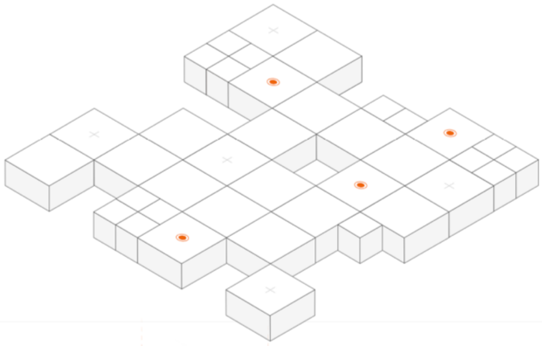
Appendix A – Overview of the TradeLens Solution (TradeLens, 2020a)

THE MARKETPLACE

An open Applications and Services Marketplace allows both TradeLens and third parties to publish fit-for-purpose services atop the TradeLens platform, fostering supply chain innovation and value creation.

THE PLATFORM

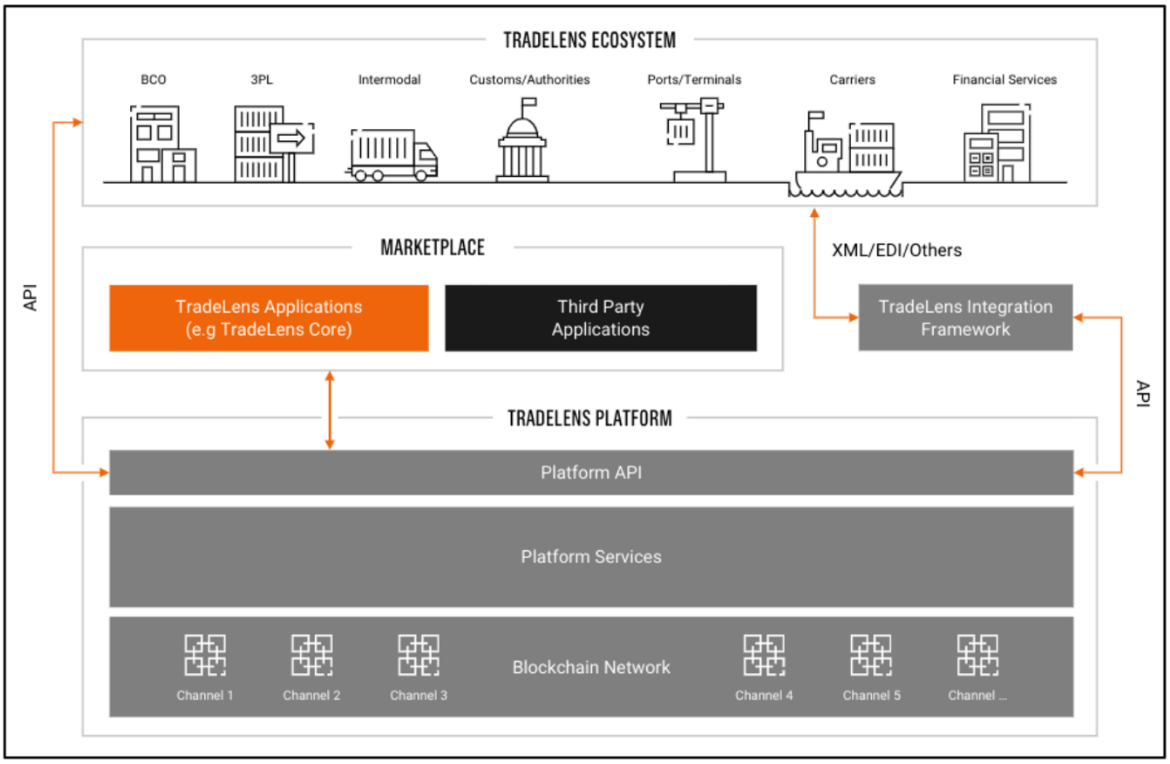
The TradeLens Platform is accessible via an open API and brings together the ecosystem through a set of open standards. Powered by Hyperledger Fabric blockchain technology and IBM Cloud, the platform enables the industry to share information and collaborate securely.



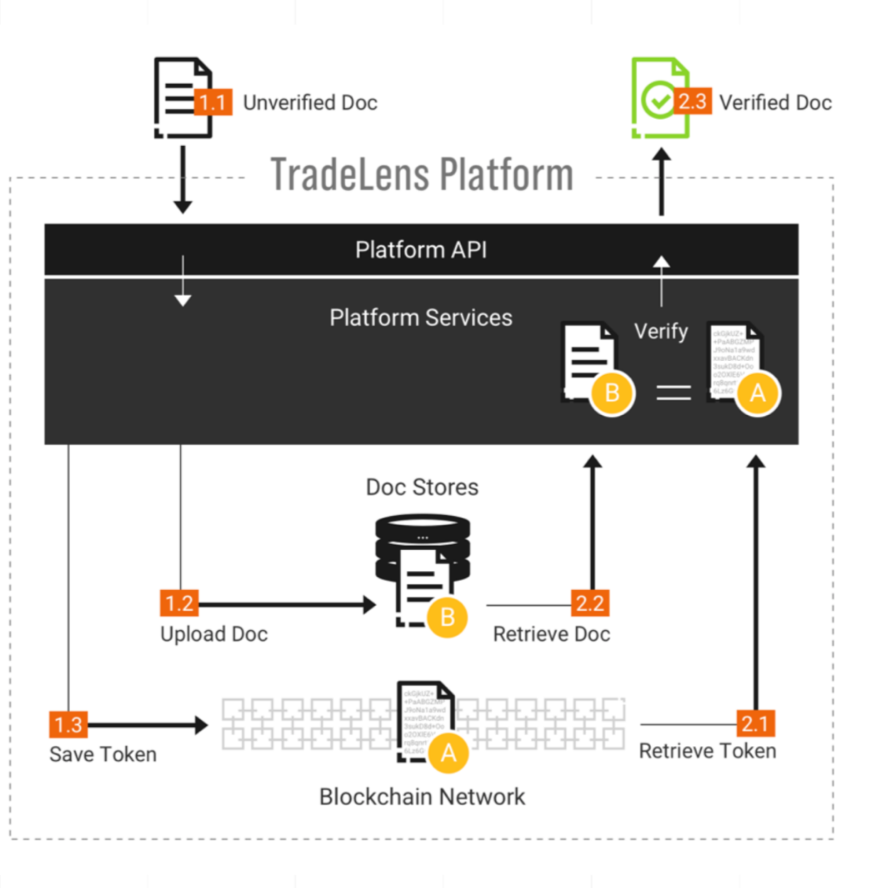
THE ECOSYSTEM

The foundation of TradeLens is its business network: shippers, freight forwarders, ports and terminals, ocean carriers, government authorities, customs brokers and more. Each entity shares information that can be tracked, stored and actioned across the platform throughout a shipment's journey.

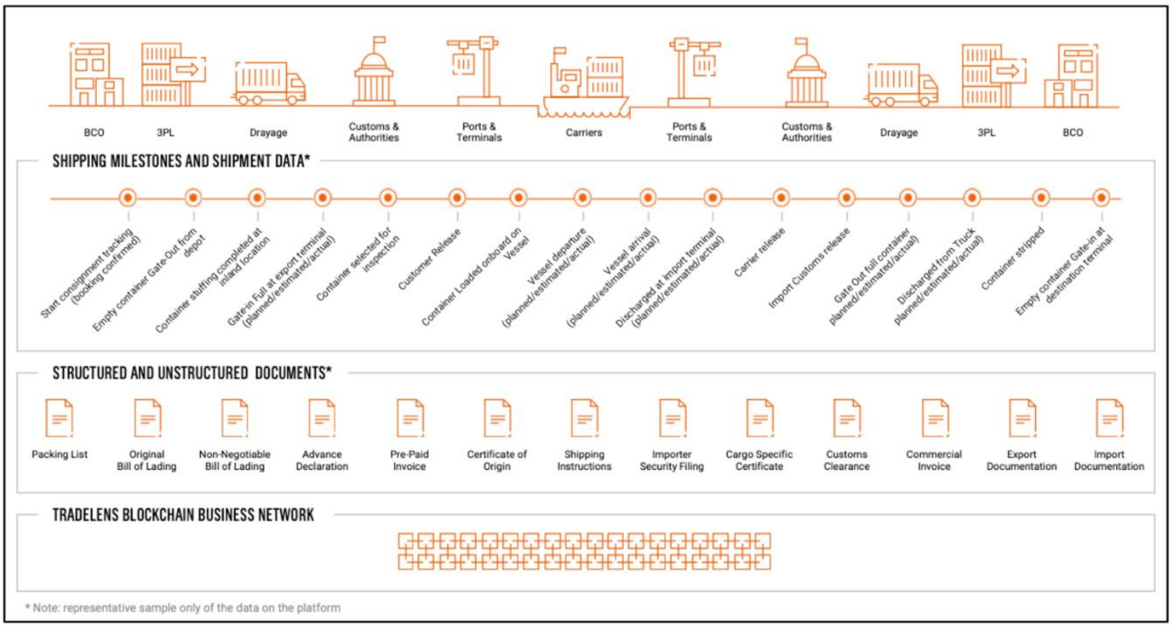
Appendix B – TradeLens Architecture (TradeLens, 2021b)



Appendix C – Versioning (TradeLens, 2019)



Appendix D – Data Sharing Concept (TradeLens, 2020b)



Appendix E – Permissioning Matrix (IBM Corporation & GTD Solution Inc., 2019)

TRADELENS	OCEAN CARRIER 1 CHANNEL	OCEAN CARRIER 2 CHANNEL	OCEAN CARRIER 3 CHANNEL	CHANNEL...
TRADELENS NODE	◉	◉	◉	◉
CARRIERS				
OCEAN CARRIER 1 NODE	◉			
OCEAN CARRIER 2 NODE		◉		
OCEAN CARRIER 3 NODE			◉	
NODE...				◉
OTHER PARTICIPANTS				
OTHER PARTICIPANT NODE	◉		◉	
OTHER PARTICIPANT NODE		◉		
OTHER PARTICIPANT NODE		◉	◉	◉