Blockchain Technology Applied to the Maritime Industry

Possible Applications and Their Consequences in Offshore Supply Chain in Scandinavian Companies

University College of Southeast Norway
Faculty of Technology, Natural Sciences and Maritime Sciences

MASTER THESIS

November 2017

ABSTRACT

This research aims presenting the possibility of Blockchain technology applications within the offshore maritime industry, while narrowing to Scandinavian and Norwegian companies for the data collection. The chosen method was qualitative research and it was performed seven interviews, being four with direct offshore operators and three with offshore supporters. The results were analyzed based on a coding book created by the author based on the topics explored in the interviews. The author also presents a framework to applying the technology to solve challenges and enhance opportunities. The results showed that the industry is driven by costs, as both enabler and barrier, and the willingness to innovate depends on such, alongside with legal requirements proposed by authorities and the need to "future proof" the fleet. The lack of knowledge about the technology and the cultural behavior within the industry are also barriers to innovation. The main challenges for this study was the lack of network required to have a broader reach within the industry and the difficulty to measure the success (or lack of it) when applying the technology, due to the lack of public available information for benchmarking and literature proposing such. Hence, a proposal for further studies is to develop such methodology by following an application in the industry.

Keywords: *Blockchain Technology, Innovation, Maritime Supply Chain, Maritime Offshore, Technology Applied to Maritime Industry.*

ACKNOWLEDGEMENTS

It is with joy that I present this work, in the expectation of sharing my achieved knowledge throughout the industry. It was a forgotten personal goal, a dream of mine to accomplish a master degree, which I did not expect to fulfil anytime soon. As life happened, the occasion of moving to Norway appeared, leading me to the attempt of pursuing this long forgotten dream. So many hours of reading, writing, worrying and not sleeping finalizes with the pleasure of fulfilling this dream, a privilege given to me, for which I thank my parents, my life partner Alex and my friends. None of this would happen without their never-ending support and patience. I would also like to thank HSN and my supervisor PhD Professor Maryna Solesvik for their guidance and to PhD Professor Anne Gausdal, whose kindness aided me into this project's completion.

"One can never cross the ocean until having the courage to lose sight of shore".
André Gide, 1925.

Table of contents

List of Figures

List of Tables

List of Graphics

1 INTRODUCTION

The Maritime Offshore Industry is part of a complex maritime supply chain that comprises a set of organizations connected and distributed globally, including other critical infrastructures that support the world trade and status-quo, such as transport and port structures. For a long period, the energy it produces came exclusively from shallow water wells, until the development of sophisticated methods began allowing exploration in other regions with greater water depths, expanding the oil and gas production globally. From 2007 to 2012, 50% of the new deposits discovered were within depths greater than 1500 meters (World Ocean Review 3, 2010), adding another layer of complexity to the operations. The extra supply and other global factors caused the oil prices to drop significantly and the setbacks that the industry suffered are still present and impacting most of the industry's operation. In Norway, the maritime yards had an annual growth rate of circa 23% between 2004 and 2008, with offshore rigs growing around 44% per year. However, between 2008 and 2014, the growth decreased in general, with the strongest drop in offshore rigs, going down to 5% per annum because of the oil prices decrease in the second half of 2014 (OECD, 2016). As a result, costs reduction became the main enabler and barrier to operations' innovation inside an industry already known for not being a pioneer in this regard. While being developed regarding oil and gas exploration and seabed exploitation technologies, it lacks innovation in its operations procedures handling, representing a challenge and opportunity to address them. Stopford (2017) argues that the solution for the maritime industry is digitalization, being smart ships, smart fleet and smart global logistics; however, it requires a great cultural change in order to allow such evolution (Stopford, Splash247, 2017, URL).

International regulations are also a key factor for the industry innovation. In 2010, it was estimated that around 600 international maritime regulations were in place globally (World Ocean Review 4, 2010). Externally driven by international bodies and the need to comply with present and future regulations, the maritime industry has been showing itself keen on pursuing eco-friendly goals, attempting to develop "green" technologies and supply chain, leading to a race towards unmanned vessels, big data, artificial intelligence and the Internet of Things exploration for industry application (Lacey et al., 2015). Other challenges have arisen from this evolution towards technology and digitalization, such as high costs, need for specialized software and personnel, shipbuilding strategy for the future and others, alongside with the cyber-security risks. The latter has been raising more concerns daily, as maritime increases its connection to cyber networks. The industry does risk assessments at regular intervals to identify possible attack paths that can be used to identify possible vulnerabilities and mitigate the risks, but such assessments provide a whole path analysis rather than a smart way of finding the most vulnerable points, creating duplicate work and adding unnecessary costs to the process (Polatidis, et al., 2017). Another technology with broadening borders and expectations has early adopters within the industry, Blockchain. Initially created to support the cryptocurrency called Bitcoin, the technology gained space and enthusiasts due to its characteristics of immutability, decentralization and time-stamped record keeping (Satoshi, 2008). Blockchain is a distributed ledger that can be anonymous and permission-less or not, but it is always a time-stamped tampering-proof ledger that disable intermediaries and eliminate businesses frictions that disrupt innovation adoption (IBM Institute for Business Value, 2016).

This study explores the possibility of Blockchain application and its early use within the maritime industry and other non-financial uses, identifying the literature and its gaps related to the subject. The lack of academic literature about Blockchain regardless of its cryptocurrency's application, especially in the maritime industry, was the key driver to this research. In a literature review of Blockchain academic researches non-related to Bitcoin, Yii-Huumo *et al.* (2016) identified no academic study of its application within the maritime area.

Another driver for this study was the previous understanding that the offshore industry lacks innovation non-related to drilling, as mentioned before on Stopford (2017). This research also focusses on the exploration and proposition of possibilities for the Scandinavian, especially Norwegian Offshore industry, as the country fosters the maritime developments, as it is a top maritime and oil nation, relying even more in cost reduction to maintain itself, while complying to regulations and protect from cyber-threats. The Norwegian government support and fosters the general maritime industry research, development and innovation (RDI) especially through the MAROFF project, which had a budget of NOK 137.5 million in 2015 (OECD, 2016).

In this regard, the main research question driving this study is: Why should the Offshore business implement the Blockchain technology to connect its Supply Chain? Followed by a second question: Which are the main advantages and limitations of its application? The author decided to apply qualitative research as strategy, which moves in an opposite direction from the quantitative, as the researcher collect data first then develop hypothesis, later testing them based on the data set collected, on a process called "analytic induction" (Nachmias & Nachmias, 2008). Therefore, this study's goal is to show the possibilities for Blockchain inside the offshore operations to solve a few of the mentioned problems, while explaining the technology to clarify its possibilities and barriers, creating knowledge and literature for the maritime industry research base. Additionally, the author presents a theory-based framework to enhance operations, allowing the creation of a scalable blueprint for operations, being also a fingerprint for audits and regulations.

1.1 Thesis Organization

This study is organized as follows: chapter 2 scans through the maritime offshore industry, with focus on its future as a pre-requisite for innovation; proceeding to explore the

Blockchain technology and examples of its application inside and outside the industry. Chapter 3 explains the methodology, ending with the results from data collection, proceeding to discussion on chapter 4, in which the author presents possibilities and barriers for the technology in the industry and the Process Blockchain Framework. Chapter 5 brings the research conclusion and discloses the possibilities for future research; then, ending in chapter 6 with the limitations for this research.

2 LITERATURE REVIEW

This chapter deals with the maritime offshore supply chain by bringing the pertinent literature to explore and summarize it, while showing why it was a pre-concept that the industry lacks innovation, thus, giving key points to understand what drove the research. It continues with exploring the state-of-the art literature about innovation to understand how they can allow or enhance its application in the industry and give examples of innovation in the industry. Finalizing, it goes through Blockchain technology and examples of its application, both in and outside maritime and offshore.

2.1 Maritime Offshore Industry and its Supply Chain – a Summary

According to Van Dokkum (2013), the offshore englobes the industrial activities in open sea, beginning at the exploration (search) for oil and gas, their exploitation (production) and their transportation to shore, being part of an industry that *"designs, builds and operates the offshore structures to allow the execution of offshore activities"* (Van Dokkum, 2013, p.69). Table 1 below details these activities and their correspondent vessels and units.

Table 1: Offshore Vessels and Units

	Item	Activity	Vessel/unit in operation
a	Searching for oil	Seismic surveying	Seismic survey vessels
b	Confirming it	Exploration	Jack-up drilling rigs, see note 1 Drilling vessels (ship shape), see note 1 Semi-submersible drilling units
c	Building the production facilities	Construction and installation of the production platform/unit	1. Crane vessels 2. Offshore barges 3. Heavy lift carrier
d	Developing the field	Drilling and completing the production wells and interconnecting the production wells with the production facility	1. Jack-up drilling rigs 2. Semi-submersible drilling units 3. Pipe laying barges or pipe laying vessels
e	Getting the hydrocarbons to the surface and processing at the surface	– Production – Depressurization and separation into oil, gas and water fractions	1. Fixed platforms 2. Tension leg platforms 3. FPSOs (Floating Production Storage and Offloading Vessel) 4. FSOs (Floating Storage and Offloading Vessel) 5. Production jack-ups or semi-subs 6. Subsea installations 7. Others, see note 2
f	Bringing the 'product' to shore	Transportation	1. Shuttle tankers 2. Pipelines, laid on the seabed by pipe laying vessels, see note 3
g	Support	– Supply and services – Maintenance and repair – Watch keeping	1. Suppliers, crew boats, anchor handlers 2. Diving and Multipurpose support vessels 3. Standby and chase vessels

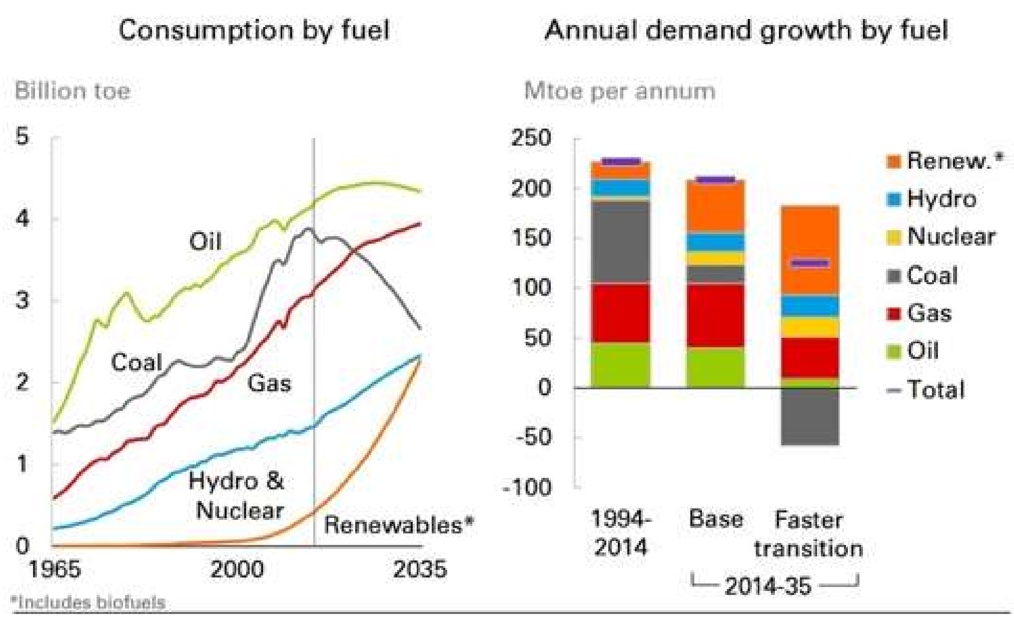
Source: Van Dokkum, 2013.

Martin Stopford (2009) classifies the offshore industry as a part of the marine resources, including offshore oil, gas, renewable energy and minerals, which represented 8% of the total marine activities in 2004, having had grown from 4% from 1999 (Stopford, 2009). Oil has become essential ever since its industrial extraction beginning in the 19th century. In 2007, 37% of the world annual oil production was from offshore, summing to about 1.4 billion tonnes; product tankers carried about 815 million tonnes of processed petroleum products worldwide, while in 2010, roughly a quarter of all goods transported by sea was oil (WOR 1, 2010). Fossil fuels have dominated the energy consumption due to their density, flexibility and global transportation logistics establishment (Vergara et al., 2012). In 2011, the Energy Information Administration estimated that 96% of the energy used for transportation derived from oil products, while the maritime sector corresponded to almost 10% of this (EIA, 2011).

As demand increased, the need for new and more sources followed, creating a trend of drilling in deeper waters. From 2000 to 2007, oil extraction from fields deeper than 500 meters increased from 44 to 157, being 91% of these in the "Golden Triangle", which is the area in the Atlantic between the Gulf of Mexico, Brazil and West Africa (WOR 1, 2010). However, greater depths mean more complex and expensive drilling operations, requiring floating production and drilling vessels or pumping stations fixed on the ocean bed (WOR 1, 2010). The discovery of offshore sources of energy triggered a completely new way of exploration and created a completely new business with it, which was not delimitated to countries boundaries or ocean surfaces, requiring a gigantic supply chain to succeed supporting the world's great energy demand. An efficient supply chain still is crucial to support the scenario discussed before. As showed in Table 1, in addition to the extraction facilities, storage facilities, heavy machinery, drilling and subsea equipment, pipelines, jack-up rigs, semi-submersible rigs and other pieces of offshore equipment compose this network. There is also a required integration between this structure and the merchant shipping fleet to transport the products, being the oil tankers and LPG and LNG carriers, allowing the resources extraction, process, storage and distribution (Stopford, 2009).

Even though the demand for energy remained growing over the years, in 2015 the oil industry has suffered a few setbacks, having the oil prices dropping by 70% from its 2014 peak (Decker et al., 2016) and barrel production costs being 60% higher than it was around 2005 (Tidey, 2015). The gas trade, however, either from conventional or unconventional sources, sustained growth and still tends to grow in the next years, as natural gas will increase continually its energy mix global share, with an expected growth at 2% per year until 2020 (International Energy Agency, 2016). The Energy Outlook for 2016, disclosed by the International Energy Agency, reassured the world reliance on fossil fuels as its primary source of energy for the next years, despite the expected boom on the renewable energies, expected to have around 15% share of energy by 2035 (Energy Outlook, 2016). Graphic number 1 illustrates this scenario.

Graph 1: Fuel Consumption and Demand



Source: EIA – Energy Outlook, 2016.

DNV GL published a report in September 2017 stating that the company expects the demand for oil to peak by 2022 due to the increased demand for light electric vehicles, until 2035. Then, gas is expected to take the lead and become the largest single source of energy as companies work to decarbonize their portfolio, which will lead in an enlarged investment to expand gas production. The company also emphasizes on the need for the oil and gas industry to remain strict about cost control and keep its innovative efforts that will lead to efficiency gains and cost saving (DNV GL, 2017).

Thus, offshore drilling and production seems to remain being increasingly necessary, and for such, technology. It has been creating discovery and reach possibilities, allowing succeeding exploring the energy sources since the very beginning, while evolving and innovating along the years. The industry seems concerned on adjusting itself for present and future environmental questions, including the ones yet to be required by the regulations authorities as well as finding technological advances in order to reduce costs, gain extra market share, differentiation from competition and a bigger profit margin. Still, 53.3% of world oil reserves are in form of restorable oils, including heavy oil, extra heavy oil, oil sand, oil shale, tar sands and bitumen (Demirbas et al., 2016). The offshore has always presented itself open to innovation due to its necessity of such. Hassani et al (2017) explains that there are five reasons in which the offshore upstream industry requires technological innovation, showed below on Figure 1. A sustainable petroleum consumption and production has been the key driver historically, however, the depressed prices and future oil and gas resources are the main motivation in the present for the upstream industry.

Figure 1: Reasons for the need of innovation in Offshore industry

1) Sustainable petroleum consumption and production;
2) Competing with other industries;
3) Automating high cost, dangerous and error prone tasks;
4) Overcoming issues surrounding the depressed price of oil;
5) Accessing future oil and gas resources.

Source: Hassani et al., 2017.

Several upstream researches have been confirming the need and opportunities for investing in technology in both the exploration and upstream as well as other areas. Facing the before mentioned challenges, cutting costs and enhancing savings has become crucial for the offshore industry. Ward (2016) disclosed that the better use of existing technologies alone could provide up to USD 1 billion in cost savings or production increase. Choudhry et al. (2016) says that maintenance costs can be reduced up to 13% when using advanced analytics for preventive maintenance, while Kendon (2016) states that the industrial use of Internet of Things can help prevent unplanned outages, hence allowing savings up to USD 3 million per week. In addition, digital enabled distribution and marketing can reduce costs up to 10% through optimized pricing models and supply chains (Choudhry et at, 2016). Consequently, innovation has become a key differentiator in order to fulfill the demand and still be profitable while overcoming the obstacles posed to the industry.

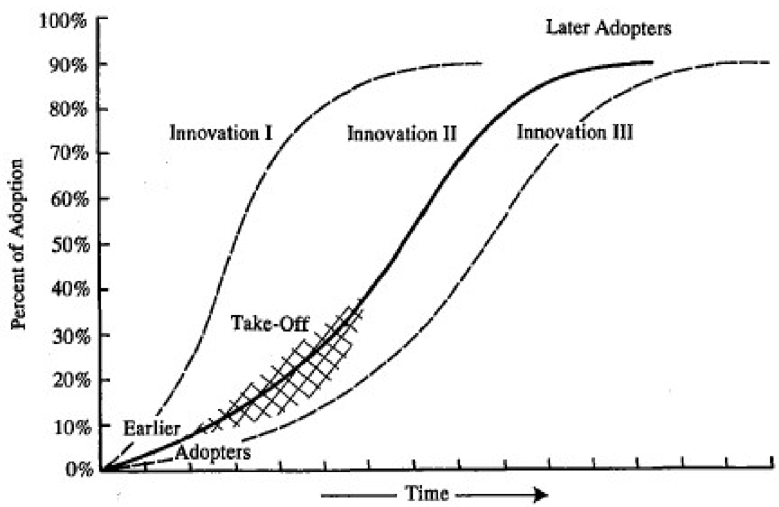
2.2 Innovation and Innovation Diffusion

Back in 1934, Joseph Schumpeter defined innovation as the dissimilar application of existing resources by re-combining them (Schumpeter, 1934). Peter Drucker included the notion of capital in 1964, saying that innovation is *"the act that endows resources with a new capacity to create wealth"* (Drucker, 1964, p. 36). Later, Thompson (1965) developed this concept to *"the generation, acceptance, and implementation of new ideas, processes,* *products, or services"* (Thompson, 1965), including the notion of acceptance and implementation required to categorize something as an innovation. Therefore, the fact of something being perceived as innovative is not enough for its implementation and adoption, whereas innovation needs to be diffused among systems in order to be successful. In his Innovation Diffusion Theory, Rogers (1995) explains that innovation diffusion is:

> *"the process by which an innovation is communicated through certain channels over time among the members of a social system. It is a special type of communication, in that the messages are concerned with new ideas."* (Rogers, 1995, p.5)

It is important to highlight that Rogers understands communication as a two-way convergence (or divergence) process between two or more individuals to reach a mutual understanding, exchanging information in order to move towards (or apart) each other. He adds that "*the diffusion of innovation is a social process as well as a technical matter"* and that the adoption rate of an innovation in closely related to *"its compatibility with the values, beliefs and past experiences of individuals in the social system"* (Rogers, 1995, p.4). He also identified four elements in the Diffusion of Innovations, being the innovation, communication channels, time and the social system, which can all be perceived in every diffusion study, campaign or program. Furthermore, the percentage of adoptions should increase within the time as the social systems began communicating the innovation, from having some early adopters to reaching out a bigger parcel of the social system, the later adopters, as innovation embracing requires a period from the time they become available to their adoption widely. The rate in which a system adopts an innovation is measured by the number of the system's members that adopt the innovation in a given period of time (Rogers, 1995). Graphic 2 below shows how these elements relate to each other through time to reflect diffusion.

Graph 2: Innovation Diffusion Process



Source: Rogers, 1995 – Diffusion of Innovations

How to speed up the diffusion rate of an innovation is a challenge for many companies and individuals. The rate of adoption of an innovation is determined by how the characteristics of an innovation are perceived among individuals in a social system, being: relative advantage, compatibility, trialability and observability (Rogers, 1995). Then, when individuals perceive an innovation as having higher levels of such characteristics, it has a faster rate of adoption. However, the system has a direct effect on diffusion rate through its norms and influence on individuals' behavior; therefore, different social systems present different diffusion rates within themselves and from each other (Rogers, 1995). The perceived complexity of an innovation also affects the rate in which a technological innovation is adopted, leading to resistance due to lack of knowledge and skills, being complexity understood as the degree to which an innovation is difficult to understand and use (Rogers, 1995). Another adoption peculiarity is the novelty degree of an innovation, which concerns the technological distance from older and current competing innovations. Overestimation or underestimation of this degree may cause problems in allocation of resources and investment decision-making, as adopting not suitable projects or rejecting correct ones, so several perspectives are investigated to determine the innovation degree of novelty, such as company, customer and product (Koc et al., 2016).

It is also important to understand the innovation itself - its costs and applications in the industry and others, how mature it is and so on, in order to have a more structured plan for its application. Tidd, Bessant and Pavitt (2005) describe the 4P's of innovation space as the four broad categories of innovation forms, which are the Product, Process, Position and Paradigm innovation. While the first deals with the changes in products/services offered by a company, the second disserts about the changes in how they are created and delivered. The Position category deals with changes in the products/services context and the last one deals with changes in mental modes framing the organization's activities. When using Tidd et al (2005) model to analyze the innovation's dimension of Blockchain application, it can be classified as radical at component and system levels, since it proposes something new to the world, a new technology and a new application that impacts the whole industry and its supply chain. Supply chain innovation is a change within supply chain network, process, technology or a combination of these, enhancing new value creation for the stakeholders (Arlbjørn et al, 2011). It is a fundamental instrument for enhancing supply chain performance, providing companies several benefits, including the improvement of customer response times, lower inventory levels, better decision-making processes and enabling visibility throughout the whole chain (Flint et al, 2005; Krabbe, 2007).

Nevertheless, not all innovations are the right fit for the whole industry, as not everything that might solve one company's problems or challenges will do the same for all of the others. Deffeys (2001) says that the industry should exploit innovation where it fits best instead of applying the same throughout the whole industry. Additionally, technical innovations create uncertainty within potential adopters due to its expected or unexpected consequences;

however, they may also represent an opportunity for reduced uncertainty due to the information base of the technology (Rogers, 1995). Therefore, when evaluating which kind of innovation is right to each industry, it is necessary to analyze deeper each part of the industry separately to make a connection to new possibilities - the company's size, goals, vision, financial capacity and its interests regarding the specific innovation in analysis. The interviews performed to collect data showed this very clear, and items number 3.3 and 4 further discusses this topic.

2.3 Innovation and the Maritime Industry

The maritime industry has established itself as a key supply chain stakeholder over the years, either by its sub-industries or by supporting businesses and allowing their growth. Shipping itself has also become a differentiator among enterprises and an advantage for them in enlarging their market reach (Hoffmann and Kumar, 2010). However, the industry faces some old known obstacles along the way, such as shipping cycles (Stopford, 2009), along with crucial challenges and choices that can mean a company's survival in the industry.

> *"The marine industry is undergoing a transformation. As well as managing today's rising operational costs and achieving cost-effective environmental compliance, ship operators are faced with tomorrow's "big decisions". Decisions about fuels, technology and whether it is possible to "future-proof" their fleet and assets." ("Lloyds Register Marine & University College London", 2014, URL)*

Maritime is one of the most affected industries by new stricter rules and legislations (Stevens, 2015) mostly enforced by the International Maritime Organization (IMO) and the European Union (EU), as well as other global treaties. How to deal with such challenges call for diverse solutions and can be a good opportunity for innovative technologies. The industry has already conducted several studies, prototypes and other innovations, such as un-maned vessels prototypes, technologic control and engine rooms, artificial intelligence for learning and training, “green” fuels and batteries, etc. Environmental compliance fleet to allow local and global trade has been a great challenge for the marine industry as the legislation keeps updating constantly to new and higher standards (DNV GL, 2014).

Data has been the focus of shipping digitalization, mainly driven by the offshore and containerized shipping, as poor information management can account for up to 20% of an operational budget (DNV GL, 2016). A typical supply chain manages a data inflow of an average of 100 gigabytes per day (The Economist, 2010), which is expected to reach 35 zeta bytes by 2020 (Tien, 2015). Jan Wilhelmsson, shipping vice president of Eniram, a Wartsila systems developing company, lead a research for the company to develop their new fleet performance monitoring system to discover how the maritime industry is spread by digitalization. His findings showed that the cruise industry is on track to real digital transformation being visibly ahead of the others, while the cargo segment is mixed, being mostly advanced on shore. He divided the industry into digital evolution categories to understand the differences, showed on figure 2. The first category includes companies with management engaged to technology and innovation to support the business. The second, the ones that tried but are still struggling, with either methodology, data, results, etc.; while the third group comprises the ones that think their operations are too complex for any solution, therefore, faded to be out of the competition soon (Wartsila, 2017).

Figure 2: Digital Evolution – Operators Categories

Source: Eniram, 2017.

In an interview in the first quarter of 2017, Dr. Martin Stopford states that digitalizing shipping is the only solution for the industry. He argues that three methods would change the business model running through shipping cycles, allowing the digitalization that the industry requires: smart ships, smart fleet and smart global logistics. However, he adds that a great cultural change is needed in order to allow such changes, aligned with Wilhelmsson's findings previously mentioned. Stopford argues that "*having the technology is a first step, but the data needs to be used in order to show performance improvement"* (Stopford, Splash247, 2017, URL). One example is the concept of digital oil fields, in which information technology tools are applied to constantly collect data, providing big data for posterior decision-making and solving possible lack of qualified labour in the future (Elatab, 2012). The maritime transport and logistics has been applying data-driven technologies application for some time, with several examples, including the first Blockchain application by Maersk, further discussed on item 2.5. One more innovation comes from a start-up called Xeneta, which has begun collecting data from container-liners and tracking over 60.000 routes globally, allowing shippers to receive real pricing information for benchmarking, rather than past static data; thus, providing pricing transparency and supporting contracts negotiations (Ball, Aberdeen

Group, 2016). Radio Frequency Identification (RFID) systems integration through Internet of Things (IoT) in order to create value for the chain based on data is another example driven by business needs. The use of RFID tags is estimated to increase to 209 billion units by 2021 (Marr, 2014; Tachizawa et al., 2015), as the sensor-based technology could reduce operational costs by 10-25% (Hahn and Packowski, 2015). IoT most current application in the industry is GPS tagging of shipping containers to assist managing their flow through transit nodes (Lacey et al, 2015). This also enables real time tracking of goods and vessels and delivers extra customer service as it provides real time information about one or more specific container. Another example are port operations. As shipping companies and other logistics modals compete fiercely for port space and resources, the collected data is not shared among the peers. This makes it extra difficult for a system to analyse and redistribute data from the port to its stakeholders, in order to optimize the use of available supply logistics; thus, turning ports in bottlenecks of everyday operations, as volumes keep increasing. The port of Hamburg estimates that the number of containers passing the port will increase from 9 million in 2013 to 25 million in 2025, and solved its data-sharing problem by requiring all parties to connect in a single data system (Lacey et al, 2015).

The innovation scenario in the maritime industry seems to be evolving and growing rapidly. DNV-GL has already started providing cloud solutions and digital offerings, such as data analysis and value creation form it. Its main software is providing integration with machine learning and between historical data analysis and future forecast, with the goal of fully integrating to the IoT in the future. Such applications will allow data-smart operations and asset management, through another technology called “Digital Twin”, which is basically an asset’s digital model representing its deep profile characteristics, such as systems, software, behaviour, needs, demands and so on, providing analysis, perception and diagnostics while completely integrated with all stages/stakeholders (DNV GL, 2016). With companies such as DNV GL, Kongsberg Maritime, etc. and several star-ups, Norway already has an established presence into the maritime and innovation development. In March 2017 it was announced a collaboration to test pilotless vehicles in the Fjord of Trondheim, among the Norwegian University of Science and Technology (NTNU) and industrial players as Kongsberg Seatex, Marintek, Maritime Robotics and Rolls-Royce Marine, becoming the world's first test location for self-directed vehicles such as unmanned ships and underwater drones (Norway News, 2017, URL).

Other countries also entered the digitalization race by fostering innovation. The Maritime and Port Authority of Singapore (MPA) launched the Smart Port Challenge 2017 (SPC, 2017) to encourage start-up and organizations collaboration, pushing digital transformation into the industry, harnessing technologies to add value to the maritime logistics chain, also collaborating with the Port of Rotterdam in the same kind of endeavour (Lim, MPA, 2017). The start-ups are gaining space into the industry as entrepreneurs discovered its financial and size potentials, already claiming attention due to their innovative concepts. One start-up called Onboard, based in Rotterdam, is bringing the Internet of Things to the maritime industry by providing an open platform with full integration with other applications and customer's internal systems, providing full insight of vessels and operations (Offshore Energy Today, 2017, URL). Another start-up, Care4C's, is focusing on bringing the telemedicine into the vessels, monitoring and collecting data about cardio vascular and sleep patterns, providing predictive analysis and proactive risk management (KNect365 Maritime, 2017, URL). While Care4C's is digging into a needed and underdeveloped field, most of the start-ups are focusing on data analytics and artificial intelligence to reduce fuel consumption, CO_2 and other emissions, route optimization and integration with other technologies and trends, such as drones use and the afore mentioned unmanned vessels. However, data and analytics software, IoT applications, etc. require intermediaries in the chain to be accessible, which adds extra steps, resources and costs to it, as they require extra labour, training, systems integration, etc. Yet, all these examples shows that there is willingness within the industry to pursue more innovations and innovative behaviour, developing the cultural aspects pointed by Stopford. Alongside, Blockchain technology could be a solution to support most of the ongoing and needed innovations, as it is a decentralized, application, building an encrypted and immutable ledger accessible and confirmed by all participants of the chain or only those who have access to it, which is explained further on item 2.4. Some companies are already researching and even applying Blockchain for its operations, mostly non-offshore, further discussed on item number 2.5.

2.4 Blockchain Technology: Aspects and Applications

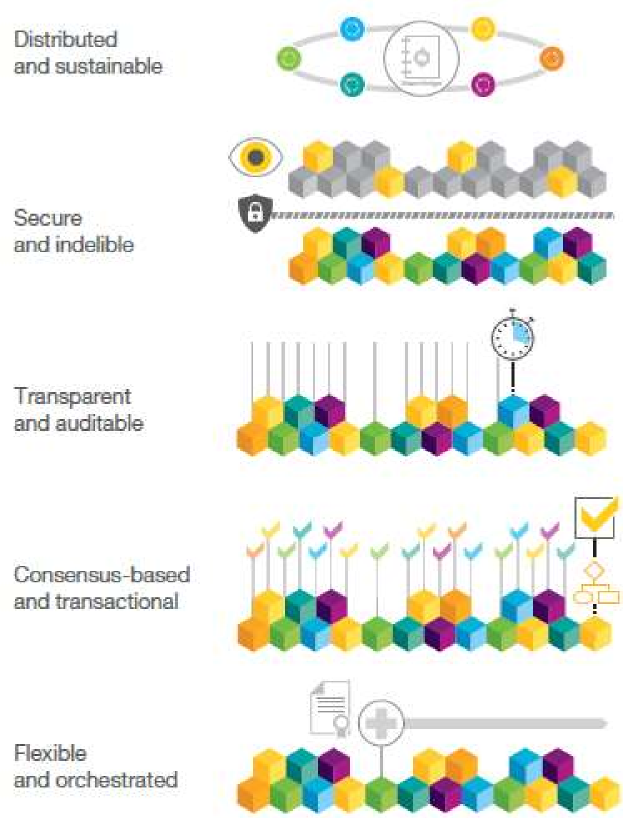
In 2008, Satoshi Nakamoto (an alias for a person or group of people who has never had its identity publicly confirmed) developed Bitcoin, which is a peer-to-peer electronic cash system that allows two parties to perform payments directly, excluding the need for a trusted third party or intermediary, in financial transactions. Bitcoin is essentially a chain connecting several digital signatures, verified by a timestamp server (Nakamoto, 2008). Nakamoto developed the cryptocurrency to enhance trust among peers to allow direct transactions, overcoming the need for intermediaries in financial transactions, thus reducing costs. He created a digital foundation, a technology to allow such, which is now known as Blockchain. Although it was created firstly together with Bitcoin, the technology evolved to be applied for several uses and businesses and should not have its concept confused with the Bitcoin's.

Since the Bitcoin start and popularization, several technology companies have begun working with Blockchain, popularizing the technology within the "*fintech*" industry, as it is known. While most of these companies are still in their startup phase, a big number of them have developed and begun incorporating others, showing the increasing interest over the technology. The biggest company to invest in Blockchain so far has been IBM, which states they expect Blockchain to revolutionize transactions the same way the Internet has done for communications, allowing increased trust and efficiency for low or zero costs (IBM Blockchain for Dummies, 2017). The company has started a big Blockchain project, investing in academia and professional training, while tailoring solutions for other companies interested in applying the technology. According to IBM, Blockchain is:

> *"a shared, distributed ledger that facilitates the process of recording transactions and tracking assets in a business network. An asset can be tangible — a house, a car, cash, land — or intangible like intellectual property, such as patents, copyrights, or branding. It can also be used to help companies manage the flow of goods and related payments, or enable manufacturers to share production logs with original equipment manufacturers (OEMs) and regulators to reduce product recalls. Virtually anything of value can be tracked and traded on a blockchain network, reducing risk and cutting costs for all involved."* (IBM Blockchain for Dummies, 2017, p.5).

The Blockchain network architecture allows its participants (nodes) to share a ledger updated through peer-to-peer (P2P) replication as per a new transaction happens. These replications mean that each node acts as both a publisher and a subscriber of the ledger; being allowed to send or receive transactions to and from other nodes; while the data is synchronized across the network as the transactions occurs (IBM Blockchain for Dummies, 2017). The timestamp server, the ledger distribution, along with the proof-of-work concept constitute the consensus model, which is the Blockchain's validation system (Nakamoto, 2008), assuring that all transactions are authenticated, secure and verifiable (IBM Blockchain for Dummies, 2017). Because of its characteristics, shown in figure 3 below, a Blockchain network allows trust within the chain for all the users.

Figure 3: Blockchain Key Attributes



Source: IBM Institute for Business Value Analysis, 2016.

2.4.1 Types of Blockchain

There are three types of Blockchain, being Public (Bitcoin, Ethereum, Litecoin, etc), Federated or Consortium (R3, B3I, EWF) and Private (company internal). The first one is the public and anonymous first created technology, which is permission-less, meaning that there is no requirement for software, allowing anyone to participate, thus, completely decentralized. This public chain uses a Proof-of-Work consensus system to validate and maintain the nodes, while the other two are types are also decentralized within their users, or in other words, centralized to the permitted users to access the network, and require a solution provider to develop the chain. Their consensus system is similar to the one developed by Nakamoto

(2008), but they differ in accessibility. Figure 4 below show their differences and particularities and their details are explained in the following items.

Figure 4: Types of Blockchain and their Characteristics

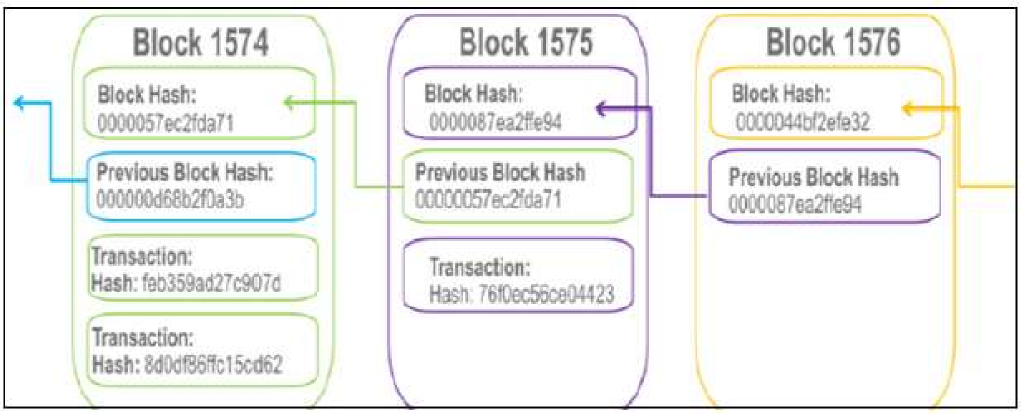
	Public No centralised management	Consortium Multiple Organisations	Private Single Organisation
Participants	Permissionless • Anonymous • Could be malicious	Permissioned • Identified • Trusted	Permissioned – Identified – Trusted
Consensus Mechanisms	Proof of Work, Proof of Stake, etc.. • Large energy consumption • No finality • 51% attack	Voting or multi-party consensus algorithm • Lighter • Faster • Low energy consumption • Enable finality	Voting or multi-party consensus algorithm • Lighter • Faster • Low energy consumption • Enable finality
Transaction Approval Freq.	Long Bitcoin: 10 min or more	Short 100x msec	Short 100x msec
USP	Disruptive Disruptive in the sense of disintermediation. No middle men needed. Unclear what the business models will be	Cost Cutting Can radically reduce transactions costs. Similar to SAP in the 1990s. Extreme cost cutting opportunities. Less data redundancy, higher transactions times, more transparency	Cost Cutting Can radically reduce transactions costs. Similar to SAP in the 1990s. Extreme cost cutting opportunities. Less data redundancy, higher transactions times, more transparency

Source: Blockchainhub, 2017, URL.

2.4.1.1 Permission-less Blockchain

This Blockchain is public, meaning that anyone can participate and contribute in the chain. It works based on Proof-of-Work system, in which each block contains a *hash*, a unique identifier or digital fingerprint of the data contained in the block, the hash from the previous block, along with batches of timestamped recent valid transactions, which also have their own hash. The timestamp server publishes the previous blocks' hashes, proving that the data must have existed at the time (since it has a hash), also including the previous timestamp in the hash, thus forming a chain reinforced by each additional timestamp (Nakamoto, 2008), shown on figure 5 in the sequence. The proof-of-work system allows the timestamp server's implementation on P2P basis by scanning for a value that when encrypted, the hash will begin with a number of zero bits. For this, it was added a nonce in the block, a number or key that needs to match exactly to the nonce created when the block/hash was created, therefore signed, until a value is found that gives the block's hash the required zero bits (Nakamoto, 2008).

Figure 5: Transaction Records in a Blockchain

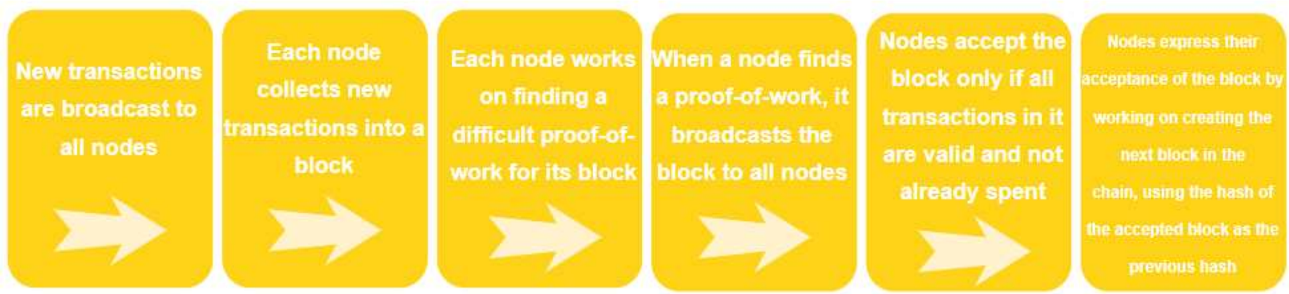


Source: IBM Blockchain for Dummies, 2017.

The hash created shows the previous' block hash as well. If any alteration is attempted in the chain, the connection to the previous block will be broken, which will then cause the whole chain to break. So, the longer the chain, the stronger it is, requiring all previous blocks to be changed to match the new information. However, a process allows searching for the nonce number for the altered block, called *"mining"*. Once any block in the chain is mined, it receives a new hash and nonce, while all the blocks in that ledger are now broken (Nakamoto, 2008). What makes this system work is that every node (user) in the chain has a copy of the chain, being the distributed characteristics of Blockchain (decentralization). Hence, if one block or more were mined to accept the alteration, the last block will have its hash altered and consequently, different from the other records from other users in the distributed chain.

Therefore, the greater amount of identical hashes in the last blocks "win" the distributed chain, keeping the immutable characteristics (Nakamoto, 2008). The mining concept also work as an incentive for keeping the Blockchain un-hackable. To discover the nonce number, several calculations are required, which demand very high processing capacities from a computer and/or server. Every time a "miner" can actually mine a nonce, it is paid a Bitcoin and the calculations become harder. Figure 6 summarizes the Blockchain network requirements.

Figure 6: Network Requirements Summary



Source: Adapted from Nakamoto, 2008.

2.4.1.2 Permissioned Blockchains

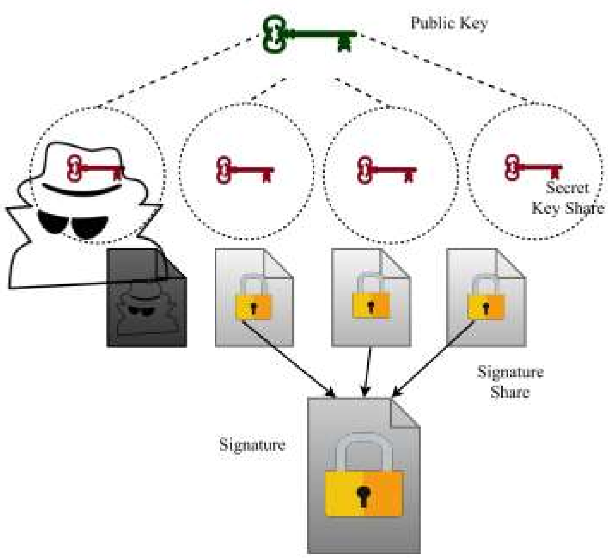
In the permissioned Blockchain, the users have a special permission to access the chain, working as a guarantee that only the allowed users can access the chain or specific parts of it, based on their assigned roles. It is also a distributed ledger; however, users may or may not be anonymous. Even though it also uses a consensus-base data validation, it does not apply the public Blockchain Proof-of-Work, since the mining process explained before takes longer to process and requires advanced and high computing power, becoming expensive for private use. Thus, the permissioned types apply the concept of "Smart Contracts", which is:

> *"an agreement or set of rules that govern a business transaction; it's stored on the blockchain and is executed automatically as part of a transaction. Smart contracts*

may have many contractual clauses that could be made partially or fully self-executing, self-enforcing, or both. Their purpose is to provide security superior to traditional contract law while reducing the costs and delays associated with traditional contracts" (IBM Blockchain for Dummies, 2017, p.17).

In this system, a private key distributed from a public key, which together form a "signature share", then creating a signature. If anyone can manage to discover the public key, this person will not be able to breach in, as there will be a private key to open the block (Stahakopoulou, Cachin, 2017). Figure 7 shows this process better.

Figure 7: Permissioned Blockchain Consensus System



Source: Stahakopoulou et. al., 2017.

All Blockchain types maintain the other characteristics mentioned before, with the permissioned ones returning to the same characteristics after the signature authentication. The main advantage from decentralization is the facility to identify and correct problems within the chain since it is easy to isolate a problematic node to investigate the matter further, then discovering if it is malfunctioning or showing signs of tampering, without losing the behaving nodes, which can continue to be available in the system (Norton, 2016). Buterin (2017) explains that there are three other main reasons for decentralization, being: fault tolerance, attack resistance and collusion resistance. The first explores Norton (2016) concept a little further, explaining that decentralized systems are less likely to fail by accident due to their reliance on separated and non-relational components. The system also becomes attack resistance due to its lack of sensitive central points, becoming more difficult to attack, destroy or manipulate; while becoming collusion resistant due to the difficulty of having most or all participants to conspire in favor of themselves over the other parts (Buterin, 2017, URL).

It is important to discover how to choose the correct type of Blockchain to the required application. To do such, IBM suggests businesses to ask themselves a few question to perform an analysis, as shown on the following figure 8.

Figure 8: Choosing a Blockchain

» Do you require a permissioned network?
» Do you need to know the identities in your business network? For example, to adhere to regulations such as anti-money laundering (AML) or know your customer (KYC)?
» Do you have frequent exchanges with others that could be automated and pre-programmed, freeing up valuable time and resource?
» Would you benefit from transaction resolution in minutes rather than days or weeks?

Source: IBM, Blockchain for Dummies, 2017.

2.4.2 Blockchain Storage and Implementation Solutions

The Blockchain, disregarding which type, keeps the last block recorded in all the chain's nodes, thus saving disk space requirements. Yet, it is necessary to build the chain somewhere. After it is decided which type of Blockchain will be implemented, it is necessary to choose the solution required to it. There are several providers in several possibilities as software and software as a service (SaaS); cloud based and Blockchain as a service (BaaS). Figure 9 details some providers and solutions. The main players so far are Amazon, with AWS BaaS, Microsoft with Azure BaaS and IBM with their BlueMix BaaS (Blockchainhub, 2017, URL). However, the main Blockchain solution is the Hyperledger, an open-source Linux Foundation Project launched in 2015 alongside with 17 other companies to collaborate for the technology's development and advance into the cross-business use. There are other open-source platforms with the same purpose, such as Iroha, a C++ Blockchain platform, and Cello, a rapid cloud platform Blockchain deployment (IBM Blockchain for Dummies, 2017). This way, developers have a single-click cloud-based environment for Blockchain deployment providing rapid smart contracts development (Blockchainhub, 2017, URL).

Figure 9: Blockchain Implementation Solutions

APPROACH	HOW IT IS DONE	EXAMPLES
IT Services	Build on request	ConsenSys
Blockchain First	Develop using the tools provided by the blockchain	Ethereum, Bitcoin
Development Platforms	Tools for IT Professionals	ERIS, Tendermint, Hyperledger
Vertical Solutions	Industry specific	Axoni, Chain, R3, itBit, Clearmatics
Special APIs & Overlays	DIY building blocks	Blockstack, Factom, Open Assets, Tierion

Source: Blockchainhub, 2017, URL.

2.4.3 Blockchain Application

As a result, the technology has several possible applications within other industries than finance, and several within supply chain, as shown in Figure 10 below. Other examples than these are education and academia, providing immutable certifications and student records; healthcare, music and other copyrighted entertainment, weapons tracking, charity, crowdfunding and many more yet to be discovered (CB Insights, 2017, URL). Even though not all companies might need the technology in their own operations, they might participate in another's network to facilitate and enhance business, comply with regulations and other requirements, among other examples, with a few applications on the Maritime Industry further explored on item 2.5.

Figure 10: Other Industries Application Examples

Financial	Public Sector	Retail	Insurance	Manufacturing
Trade Finance Cross currency payments Mortgages	Asset Registration Citizen Identity Medical records Medicine supply chain	Supply chain Loyalty programs Information sharing (supplier – retailer)	Claims processing Risk provenance Asset usage history Claims file	Supply chain Product parts Maintenance tracking

Source: IBM Corporation, 2017.

2.5 Blockchain in Maritime and Offshore Industry

While still not completely diffused within the industry, the technology has been gaining space into discussions and possible applications. One good example is the Marine Transport International Limited (MTI) freight forwarder. In 2016 last quarter, MTI announced that was using a public Blockchain ledger called TrustMe™ to comply with the new verified gross mass (VGM) requirements of packed containers, implemented from July of 2016 by the Contracting Governments to the International Maritime Organization's SOLAS treaty (International Convention for the Safety of Life at Sea). The new regulation transferred to the shipper the responsibility of ensuring that the right VGM is provided to the terminal or carrier prior to being loaded to the vessel. The company then began using Blockchain through TrustMe™ in order to provide a permanent and visible record to port officials, shippers and cargo owners; thus eliminating the need for data intermediaries, private databases, logs and spreadsheets (Finextra, 2016, URL).

The technology has also been applied to enable single energy trade within commodities markets. A renewable energy trader, Volt Markets, implemented a public Blockchain to provide assurance of trade and absolute tracking for renewable energy certificates, while in January 2017, another trading house, Mercuria, carried out the technology on a large oil trade within ING and Société Générale banks (Dhanji, EY, 2017, URL).

Several other uses are possible within the maritime industry, mainly in order to solve regulation compliance, documentation issues and origin assurance as well as to support communication and automation. Blockchain could solve the digitalization of the Bill of Lading (BoL), essential document within shipping, providing an immutable chain accessible by all parts required within 10 minutes of its creation. The BoL is a contract of carriage and an ownership/receipt document, and by the Maritime Law, the original version of the document is required to be produced by the consignee to allow cargo delivery. This document is frequently delayed due to banks and other issues, which leads to the cargo usually arriving at ports before the original BoL creation or to BoL fraud. Such includes the document being produced and signed before the actual loading of the vessel or being altered after cargo delivery; with forged signatures, bank guarantees and wrong description of cargo (UNICITRAL, 2013).

The Blockchain application to support BoL was one of the first researched applications within maritime industry and is probably one of the most advanced ones, alongside with containerized shipping, already having adoption frameworks and models, such as shown in figure 11 below. An Israeli start-up called Wave is focusing on creating a paperless trade for shipping trade by applying Blockchain to create and track BoL's, Letters of Credit and the whole chain. Its main competition, Skuchain, located in California, USA; believes in the evolution of the "collaborative commerce", being the integration of all parts of all supply chains involved in commerce, exchanging information and collaborating towards commerce (BNC, 2016, URL).

Figure 11: Blockchain enabled Bill of Lading

Source: IBM Institute for Business Value Analysis, 2016.

Scandinavian companies are not falling behind on these innovation and possibilities. Statoil is another company working actively to apply the technology into their Supply Chain. The company made a project in partnership with a startup called "The Innovation Factor" to approach academia in order to research the field, applications and so on, presented on the Oslo Innovation Week on September 28th 2017. The project, called "Shaping the future of energy - How can technologies like Blockchain enhance Statoil's inherent advantage as a responsible and sustainable energy producer?", discussed what Blockchain is, its potential in the energy industry and how Statoil can integrate these technologies in their value chain, making it more transparent and sustainable, also benchmarking which industries have already adopted the technology to discover what can it learn from them (The Innovation Effect, OIW, 2017). However, the biggest Blockchain project within Maritime so far has been with the

Danish shipping leader Maersk. The company collaborated with IBM to create a trial application of Blockchain to test the technology in 2017 first quarter, following an order during all its stages in the Fabric Hyperledger, an IBM open-source Blockchain, although only providing access to the parties involved through customized credentials (keys). Not many nodes were created, but the company disclosed that it was enough to see the technology's possibilities within shipping supply chain and expanding it to their other businesses, such as finance and oil and drilling, in addition to its application in tracking and managing empty containers, insurance and fighting fraud (Coin Desk, 2017, URL). A new trial with insurance has begun on 2017 third quarter, as the company disclosed its interest to

> *"solve real customer problems and create new innovative business models for the entire industry, ..., not only to reduce the cost of goods to consumers, but also make global trade more accessible to a much larger number of players from both emerging and developing countries"* (Maersk, 2017, URL).

3 RESEARCH METHODOLOGY

This chapter aims on describing the research base and the theory utilized in pursuing the most scientific results to find the answer of the research questions showed below. It begins with describing the research topic and questions that have driven this research, followed by the chosen strategy and design. Then, it proceeds to explain how the data collection was performed and moves forward to the reliability, validity and ethical considerations of this research, ending with the data analysis explanation and details.

3.1 Research Topic and Question, Design, Strategy and Data Collection

The research topic was chosen based on the researcher's personal interest of technology and its application to the maritime industry. According to Nachmias (2008), the emotional involvement between the researcher and its work is beneficial as it assists the researcher in coping with inevitable problems in every research project and turns the research more rewarding personally. The main research question driving this study is: Why should the Offshore business implement the Blockchain technology to connect its Supply Chain? It is followed by a second question: Which are the main advantages and limitations of its application?

The research strategy consisted on qualitative research. The qualitative research field moves in an opposite direction from the quantitative, meaning that the researcher collect data first and then develop hypothesis and test them based on the data set collected, on a process called “analytic induction”. Then, the researcher attempts on building theory, which in this process, consists of discovering and connecting relationships between categories and observations (Nachmias & Nachmias, 2008).

For this study, the sample was defined in order to collect data and make inferences for the whole of cases, meaning the population. According to Nachmias (2008), the goal is to enable the generalization of the results encountered and measured from the sample in the whole population. The population aimed for data collection were the companies working in the Norwegian Offshore industry, whether these companies are Norwegian companies with operations in and/or outside Norway or foreign companies operating in Norway. Therefore, the estimated population is finite, consisting of a countable sampling units registered for offshore operations in Norway. However, this number is enormous and not all of it is relevant for this study. Since this is a qualitative research, the author decided on take small samples of the offshore stakeholders to have different insights from their different perspectives. Therefore, the interviewed companies were chosen based on three criteria, being their presence in the offshore business, their interest and connection with innovation and known their use and proximity to technology into their operations. These criteria did not discriminate whether the companies were active or support players in the offshore business, since it was on this study's interest to discover similarities and differences in both perspectives.

The choice for data collection was semi-structured research interview. According to Bryman & Bell (2015), qualitative research commonly uses the research interview as an instrument for data collection. The actual interview process is flexible and questions are formulated and proposed based on the interviewer practice (Bryman & Bell, 2015). Data was collected through questionnaires and interviews with the chosen players within the industry. The interviews were conducted live, over the telephone and Skype, and were recorded. It was conducted six interviews based on an interview guide, consisting on 15 open-ended questions and seven closed-ended questions, in an attempt of facilitate the coding creation for the further data analysis. The interviewees were posed the questions in a funnel sequence, in which each successive question is related to the previous one in a progressive narrower scope (Nachmias & Nachmias, 2008). This was decided to get a broader perspective and then narrowing to the core of the interview. Then, the data was processed and analyzed through Nvivo software and went on to coding to disclose the findings – this is further explained and discussed on item number 4.

The main goal for the data collection was to discover within the industry how they see the topic and its applicability in their fields as well as their willingness to do so. Blockchain is still an unknown technology for the majority of industries, having had its application mostly into the financial industry, since it has been developed for the crypto-currency Bitcoin as previously elucidated. It is also a very new topic. In a published systematic review of Blockchain researches without Bitcoin performed by Yii-Huumo *et al* (2016), only 41 relevant studies on the topic were identifies, which have all been published after 2012, being 56% of them published on 2015. This trend not only confirms how fresh this topic is, but also shows how intense the interest on Blockchain is growing. They also identified that the largest number of published papers on the topic was in United States (14.6%), followed by Germany (13.3%) and Switzerland (12.2%), showing the higher geographical interest on the topic (Yii-Huumo et al., 2016).

3.2 Reliability, Validity and Ethical Considerations

Validity and reliability are concepts to give and verify trustworthiness to a research study, establishing confidence to the results (Lincoln & Guba, 1985). While validity offers quality to the study (Stenbacka, 2001), reliability concerns whether the research results are replicable (Bryman, 2012). Validity is divided between internal and external. The first assesses if the theories developed from researchers' observations are counterparts with the observations and data themselves, while the latter measures the level of results generalization through social settings (Bryman & Bell, 2015). A triangulation process was performed to ensure validity, defined by Creswell & Miller (2000, p. 126) as "a validity procedure where researchers search for convergence among multiple and different sources of information to form themes or categories in a study". This involved an extensive literature research about the stakeholders, Blockchain technology and innovation, which later assisted on eliminating bias from the collected data and assisted increasing the research truthfulness.

Reliability is the concept concerning whether the research results are repeatable, being the external reliability to assess the level of extent in which the study can be replicated, while internal reliability assess the existing consensus (or not) among the research team about the gathered information (Bryman & Bell, 2015). The difficulty facing replicating this study is that technology is in constant evolution and change, as well as the study's interviewed companies and actors. It is a challenge facing qualitative research "to 'freeze' a social setting and the circumstances of an initial study to make it replicable" (Bryman & Bell, 2015, p.400). However, Lincon & Guba (1985, p. 316) states that "since there can be no validity without reliability, a demonstration of the former is sufficient to establish the latter", meaning that once a study is valid, it is also replicable. This was later indicated also by Patton (2002), saying that reliability is the consequence of a study's validity. Nevertheless, once put in perspective the variables existing in the time in which this study was conducted and its stakeholders, it is possible to replicate it and likely to achieve the same or very similar results. The collected data also show similarities among the stakeholders groups during the interviews and in their response to the questionnaire, which was design to collect as much information possible, based on literary research. These encountered patterns satisfy the consensus required in internal reliability.

Regarding the ethics aspect, all the interviews were recorded with the knowledge and agreement of the interviewee and they were all proposed a confidentiality agreement, which was based on the template provided by HSN. All data disclosed in the data analysis and discussion were done based on agreement between interviewer and interviewee. Nevertheless, no company or employees names were disclosed based on anonymity principle, in which the information provided by individuals and individuals themselves are separated and the readers cannot identify and/or link any specific information or part of it with any particular participant (Nachmias & Nachmias, 2008).

3.3 Data analysis and Results

The chosen methodology to analyze and measure the collected data was to create a coding scheme. According to Nachmias (2008, p. 304):

> *"measurement consists of devising a system for assigning numbers to observations (...) the number assigned to an observation is called a code. This code should be consistent across cases of units of analysis when the same condition exists"* Nachmias (2008).

The application of inductive coding was decided and applied as, according to Nachmias (2008), it is indicated in cases where there is little theory on the subject to inform the researcher about which type of responses to expect from the data set. In the inductive coding scheme, the most frequently stated responses are included in the scheme to proceed with the data analysis.

> *"In inductive coding, the researcher designs the coding scheme on the basis of a representative sample of responses to questions (particularly open-ended questions), data from documents, or data collected through participant observation."* (Nachmias & Nachmias, 2008, p. 307).

There were seven interviews performed in total, being four with Offshore operators and three with suppliers, which were divided by these two categories and given numbers from 1 to 4, for Offshore operators players, and 1 to 3 for Offshore support players, in order to distinguish them without identification. This division allowed reaching more depth for the results, being able to compare similarities and differences between both groups and among all interviewees. The collected data through the interviews was processed via NVivo software, which allows the organization of data and facilitate the coding process and the codebook construction. The access to the software was possible through USN infrastructure, which includes the required licenses for its use. The software facilitated and speeded up the data analysis process, as it converts audio files into text, excluding the need for audio transcribing, allowing faster and richer results. It also decreased the possibility of errors and of leaving data out of the analysis. For the data transcription, an online tool called Trint was used. It is a speech-to-text tool, which recognizes the words to create editable documents embedded in the tool, allowing easy correction after the recording's rough base has been transcribed to text. After all files were transcribed, checked and separated into their proper documents, it was possible to determinate the coding scheme and create the codebook, allowing the transformation of the raw data in output for results analysis and discussion. Fifteen codes were created in correlation to the interview guide and its questions, then, applied to the text documents analysis. The results' summary of the codebook and code incidence is shown on table 2 below.

Table 2: Codebook for Data Analysis Summary

Name	Sources	References
1. Innovation	7	67
1.1. Company Innovation	7	52
1.2. Company Willingness	7	40
1.3. Industry Innovation	7	29
1.4. Industry Willingness	6	24
2. Technology	7	77
2.1. Company Technology	7	66
2.2. Industry Technology	7	29
2.3. Blockchain	7	18
3. Resources	7	75
4. Challenges	7	42
5. Improvements	7	26
6. Audits	6	11
7. Corruption	7	7
8. Comments	7	34

Source: the author, from NVivo, 2017.

Then, the interviews results were analyzed further based on the sources' given importance to each node, measured by the extension percentage of that topic coverage in relation to a code/node and their incidence among the interviews, shown on tables in the sequence. Table 3 shows the interviewees perception on how much innovation is needed in general and divided by their own companies and in the offshore; while Table 4 shows their perception regarding their company's and the industry's willingness of investing in innovation.

Table 3: Innovation Importance Perception

	1. Innovation		1.1. Company Innovation		1.3. Industry Innovation	
	Coding Coverage	Coding References	Coding Coverage	Coding References	Coding Coverage	Coding References
1 : Operator 1	8,48%	10	6,18%	7	6,86%	7
2 : Operator 2	10,60%	10	9,80%	8	0,31%	1
3 : Operator 3	12,49%	9	10,84%	8	1,66%	1
4 : Operator 4	8,85%	7	5,28%	3	8,85%	7
5 : Support 1	8,70%	7	8,70%	7	2,49%	2
6 : Support 2	8,84%	13	6,45%	9	4,51%	7
7 : Support 3	8,30%	11	7,61%	10	4,07%	4

Source: the author, from NVivo, 2017.

Table 4: Innovation Willingness Perception

	1.2. Company Willingness		1.4. Industry Willingness	
	Coding Coverage	Coding References	Coding Coverage	Coding References
1 : Operator 1	5,79%	6	6,23%	6
2 : Operator 2	8,18%	6	0%	0
3 : Operator 3	2,63%	3	1,66%	1
4 : Operator 4	5,28%	3	8,42%	6
5 : Support 1	7,66%	6	1,45%	1
6 : Support 2	5,10%	7	4,02%	6
7 : Support 3	7,56%	9	4,07%	4

Source: the author, from NVivo, 2017.

The same logic was applied regarding technology, having the tables below showing the results. Table 5 explores the technology perception in general, within their companies and throughout the industry, while Table 6 explores their perception of Blockchain.

Table 5: Technology Need Perception

	2. Technology		2.1. Company Technology		2.2. Industry Technology	
	Coding Coverage	Coding References	Coding Coverage	Coding References	Coding Coverage	Coding References
1 : Operator 1	14,16%	16	12,62%	13	5,32%	5
2 : Operator 2	18,85%	13	11,35%	9	2,54%	1
3 : Operator 3	10,91%	8	10,91%	8	5,64%	3
4 : Operator 4	10,91%	9	6,83%	6	8,07%	7
5 : Support 1	11,75%	8	10,91%	7	3,46%	2
6 : Support 2	14,58%	11	14,09%	10	5,82%	4
7 : Support 3	12,03%	12	12,19%	13	6,62%	7

Source: the author, from NVivo, 2017.

Table 6: Blockchain Applicability Perception

	2.3. Blockchain	
	Coding Coverage	Coding References
1 : Operator 1	0,75%	2
2 : Operator 2	6,20%	4
3 : Operator 3	1,50%	1
4 : Operator 4	2,60%	2
5 : Support 1	0,84%	1
6 : Support 2	7,57%	4
7 : Support 3	4,55%	4

Source: the author, from NVivo, 2017.

It is possible to note such similarities and differences by examining the coded text by node and their relationship to the coding sources (interviewees), thus, generating a deeper perspective of what each source believes regarding each node. For such analysis, the author created frameworks with the mentioned data, separating the sources by attribute, being: main operators or supporters in the offshore industry. These frameworks shown in the tables in the sequence, being divided by: Innovation, Technology and others, including the most interesting comments from findings on tables in the sequence.

Table 7: Operators Innovation Perception Framework

	1. Innovation	1.1. Company Innovation	1.3. Industry Innovation
Opperator 1	"I see more possibilities in the software technology to improve our industry than just the drive for... Like battery ships or power, electrical ships. I think the benefit for industry can be much more in smaller things."	"Yes. (innovation is needed in the company) Because everyone has to be in the forefront of innovation in order to succeed and, not fall behind the other competitors. At the same time it's important to look at what type of innovation you choose."	"Conservative… I don't know the industry that well, but I mean, it's a trend as younger people move in. They will definitely see the need for innovation."
Opperator 2	"company needs to innovate to "fight the big dogs"."	"really need innovation (since the company is) not following any big/new systems as it is following what the big companies are doing in that regard."	"industry needs innovation as well"
Opperator 3	"We always have to go forward. We also need innovation to get down the prices, operation costs or whatever."	"we are also developing systems and ROI's for instance. So it's brand new, so it's one of a kind and sort of things like that."	"Yes, it's needed."
Opperator 4	"everything is developing faster and the maritime industry has to in a way, follow this if not, they will be out"	"if some innovation, some systems or software would actually help getting the work even more smoothly."	"Yes it is. And if you look back in shipping industry, of course there has been innovation but, is going very slow. But I believe it will go quicker now in the next 20 years than compared to the past 20 to 40 years."

Source: the author, from NVivo, 2017.

Table 8: Supporters Innovation Perception Framework

	1. Innovation	1.1. Company Innovation	1.3. Industry Innovation
Support 1	"I say yes to innovation. (…) we are innovating a lot. Innovation is needed in the industry, yes for sure (…) innovation that is more into technology."	"We have a separate research and development department. And last year, in 2014 I've spent almost 55 million U.S. dollars only on research and development. But in 2015 it went down to 32 million, (due to) saving money. But still, if we didn't believe that research was important then they would have shut it down completely."	"Innovation is needed in the industry, yes for sure"
Support 2	"(yes, we need to find) opportunity to innovate and go forward with technology." "if these classification societies say something about this technology, something is going to make it happen faster or would make it happen, yes, it's possible."	"In terms of the equipment that we deliver we are quite well positioned if you compare to the other companies. And now there are some some guys working there in new technology, new equipment to make it cheaper because that's the drive again, money."	"I've been working with offshoring engineering for more than 10 years and it's all about cost. So it's a cost that leads the company" "it all depends on costs. You have to show your finance director that in years or decades these are revert in a huge beneficial for the company otherwise they will not approve it never."
Support 3	"I'd like to see more innovation. I want to see more and more ways to work. (…) But when you do everyday work in a very old way (…) It's difficult. (…) they have to innovate."	"So innovation (...) is something that (...) is very focused on the technical part and how we do the installation. On one hand you have the focus on having the best technology for installing products. But on the other hand, (we) are not very modern when it comes to how to manage the projects, such as the tools that we use."	"For technology they're kind of advanced, but when it comes to managing projects is very conservative and there is a saying that the people working on the gas are cowboys."

Source: the author, from NVivo, 2017.

Table 9: Operators Innovation Willingness Perception Framework

	1.2. Company Willingness	1.4. Industry Willingness
Opperator 1	"we're very early on the I.T. innovation. So moving to new I.T. platforms constantly to meet the needs of the business." "The company is willing to take risks if the benefit is there."	"It will increase as the older generation of the management of shipping companies goes up. Because, younger generation will much quicker understand the potential, the technology and the use of new technology."
Opperator 2	"willing to do so but without being pioneers (...) it does not have to be fully developed, but need to be already in place somewhere else in the industry"	"money is the key, as in higher costs being the limitation and lower costs the enabler."
Opperator 3	"we need (…) to invest in this NOX reducing systems. So we need to invest in technically to innovate."	"The cost is the main driver for the moment."
Opperator 4	"very focused on cost and low cost. And of course this will probably generate a lot of cost before it's saving."	"it's a quite conservative business and, things take a very long time. And normally, what is implemented ashore to society and banking and so on is decades ahead of what they are doing offshore on ships."

Source: the author, from NVivo, 2017.

Table 10: Supporters Innovation Willingness Perception Framework

	1.2. Company Willingness	1.4. Industry Willingness
Support 1	"...we are willing to spend money on newer and more developed equipment, than just buying old stuff. So, we are interested in new technology. But on the maritime side, we're not developing it. It cannot be compared with the seismic side to put it that way." "And we are developing our own systems."	"...this is not giving us any value today, this is giving a value maybe five, ten years from now. But still we believe so much in it, that it's still consuming a lot of money."
Support 2	"if it's something already used by an order of companies and it's proved that it's a good solution that's much much better (...) You have something that is proved is used and if you have in many companies that use it before you have some good and bad experience that you can you can you can use that argument when you're in that discussion."	"It doesn't matter if the companies are not actually interested in solving most of modern equipment. But the most feasible to do what they have to do in the minimum prices possible so it will be a price that will lead the market to go with these new technologies or not."
Support 3	"I really think (we) should do it. I think (we) will eventually do it but, it's going to take time. But you see now (we) have more young engineers, more young people working (...) have the pressure of other industries (...) Renewable stuff so, have to change."	"when (the industry is) this big, it's more bureaucratic, it's very difficult to change things. And also the industry is very conservative when it comes to these kind of things." "In this industry you need something that is proven. People don't like to do things for the first time."

Source: the author, from NVivo, 2017.

Table 11: Operators Technology Perception Framework – Company and Industry

	2.1. Company Technology	2.2. Industry Technology
Opperator 1	"we rely much more on Big Data (which is) coming with full speed. If we can analyze what is happening on our units, we can predict what will happen based on big data. So the more data we can get into innovative systems, the easier it will be to analyze the market and our own industry (...) We have a look at predicting accidents, in order to avoid accidents. (...) On which unit, where there has been lack of maintenance."	"Well, the actual marine industry... If you look at ship owners, they don't need to invest so much. It's more that the companies who develop this as a market for the industry.. Industry as a market. They will see the opportunities and will have to invest heavily in it. But we go off the shelf and we just pick, we don't invest so much in R&D."
Opperator 2	"company is not following any big/new systems as it is following what the big companies are doing in that regard (...) investing over what other companies are interested on doing, due to high costs and taylorization, which is expensive"	"operations suffer other down points, like offshore internet speed - eventhough it is at its best right now, it might not be enough as one might not be able to send/receive information through systems, leaving everything to be sent over email."
Opperator 3	"we are in the high end (...) we are also developing systems and ROI's for instance. So it's brand new, so it's one of a kind and sort of things like that. (...) We do it (develop) internally and, we also use contractors (...) if we know how to do it ourselves all the way we build it, we test it and we implement it."	"if the idea comes from outside, it is harder to make it possible, (…) for then it is no longer unique anymore."
Opperator 4	"it's better to go for some system which are off the shelf and then slightly adjust on that to your your needs, compared to (...) make our own system". Maybe in shipping, (...) but apart from them I don't think there are very many that will benefit."	"it's a quite conservative business and, things take a very long time." "need to invest in technology, however (...) they are not pioneers. I am quite sure that they will come, but they will come after it's already implemented in something else."

Source: the author, from NVivo, 2017.

Table 12: Supporters Technology Perception Framework – Company and Industry

	2.1. Company Technology	2.2. Industry Technology
Support 1	"We have streamlined a lot, and we are still doing. So we have e-mail of course. In-house system. And then we have the purchase, maintenance, logistics... All of that we have in another system. We have a search system, which is actually just our intranet with all the procedures and everything. So with these three systems, that covers maybe ninety five percent of our needs."	"one big problem with the maritime industry is of course the band with on the internet on board. So, if we could we would like to stream everything directly on shore but, it's too costly. I think we have maybe three gigabytes or something a day. That's a total of $10000 a month or something. So that's the limiting factor."
Support 2	"we are actually quite bad in terms of data, documentation and contol processes so that we have a huge job to do."	"(in the bigger companies) the processes are quite well organized and much more independent. (...) There are much more technology involved so when you see for example when you finish one document for example you do it everything on line in the send to the orders to review and then the revision comes online to you."
Support 3	"(...) we've been producing oil for 50 years or so. The same way but, every year is incremented. You increment the amount of work you have to do for the same type of project, the amount of documentation, the amount of engineering.. (...) So now it's like 10 times more ground work you have to do to deliver the same thing. So the idea is that now you have to go back to more simple ways to deliver the projects."	"(...) most companies (...) are very focused on the technology to either extract hydrocarbons, (...) fabricate equipment or install equipment. But not so much focus on how to do more efficient business processes."

Source: the author, from NVivo, 2017.

Table 13: Operators Technology Perception Framework – General and Blockchain

	2. Technology	2.3. Blockchain
Opperator 1	"It will increase as the older generation of the management of shipping companies goes up. Because, younger generation will much quicker understand the potential, the technology and the use of new technology."	"It's definitely much faster and it will reduce bureaucracy. It will have to incorporate... Well, it appears to have better control even. (...) I would say opportunity. So, you have an opportunity to get to our big data and block chain will further prove that."
Opperator 2	"company is really investing on people due to the higher knowledge involved (paying for courses, travels, higher education costs, etc), while technology can be achieved through 3rd parties/consultants as needed." "For the application of a new technology, it does not have to be fully developed, but need to be already in place somewhere else in the industry."	"Blockchain technology could help operations for sure, but could be too expensive and other aspects need to be checked. The company could apply it to enhance operations but would need more studies to prove its efficacy."
Opperator 3	"The cost is the main driver for the moment."	"could be a possibility to develop further, to see the possibilities for our company to be good."
Opperator 4	"believe very much in the technology (...) for example oil production: if this fails it's a major disaster"	"it is something that could be implemented. (...) but normally, what is implemented ashore to society and banking and so on is decades ahead of what they are doing offshore on ships."

Source: the author, from NVivo, 2017.

Table 14: Supporters Technology Perception Framework – General and Blockchain

	2. Technology	2.3. Blockchain
Support 1	"we are willing to spend money on newer and more developed equipment, then just buying old stuff. So, we are interested in new technology."	"Payment probably (it) would be good (…) tracking costs etc, for sure."
Support 2	"technology is essential, it should be done always."	"I think there is a good opportunity. (…) documentation, we have a couple of equipment that should be tracked and while they are in operation, (…) I really believe that it's a good opportunity to innovate and go forward."
Support 3	"I think it's quite outdated. On one side you have resistance from the people that have been there for a very long time, to try something new. But you also have the resistance from the I.T. Department for example because (...) to implement something new, you have to stand to some 4000 people or 30, 40000 people. So it's quite a big change for them to do something."	"I think for the contracts part it's going to be good. (...) To make sure all the offices and different companies communicate in the common way. I think that will help when we do the end of the month report for the projects. These guys spend like three days working nonstop 12, 14 hours a day just to make sure everything adds up with its projects so, it's not very straightforward."

Source: the author, from NVivo, 2017.

Table 15: Operators Perception Framework – Resources and similar

	3. Resources	4. Challenges	5. Improvements
Opperator 1	"It has proven that it (in-house made software) becomes too expensive because, what you cost to make you have to maintain yourself. And the maintenance cost of custom made products is on the ship owner. So, by not looking at yourself as so special then, you will reduce your cost and if you just pick off the shelf products, they are usually more than sufficient. (...) not to rely on third parties to maintain the software, (it) has proven to be very expensive due to the high consultancy costs in the industry. So, it's very important to have this knowledge in house and to quite rapidly cut the tie with the consultancy agency. So that's a cost driver for our industry."	"(...) the actual cost is with the training, the competency, the change of systems, etc. (...) What the total cost and the life cycle cost of this is (...) it's (about) what benefit it does to the organization and, is this what will change the actual organizational outcome in the next two or five years." "Safety is one, I.T. security and (...) globalization, nationalization - Protection"	"We have an innovation project (...) We look at predicting accidents, in order to avoid accidents. As a barrier, we collect big data and we can pinpoint where the next accident may happen. On which unit, where there has been lack of maintenance. Where is maintenance required based on Big Data, analyzing accidents. We can analyze everything through Big Data."
Opperator 2	"For a smaller company, technology is important, but people knowledge might be more important." "money is the key, as in higher costs being the limitation and lower costs the enabler. Systems can be expensive - is this one worth for a smaller company?"	"people with high education levels (skilled), available low-cost technology that applies for the whole operations."	"company is really investing on people due to the higher knowledge involved (paying for courses, travels, higher education costs, etc), while technology can be achieved through 3rd parties/consultants as needed."
Opperator 3	"The cost is the main driver for the moment - the main driver and the main challenge to everything is located in the cost."	"To improve the efficiency." "Oil price and (...) Trump and Brexit. We're used to getting some challenges between the EU and Russia. (…) Political challenges, so we don't have any control of them."	"we are also developing systems and ROI's for instance. So it's brand new, so it's one of a kind and sort of things like that."
Opperator 4	"One challenge when you have implemented these types of systems, which are expensive to implement or at least generate some cost to implement, is to kick them out and say okay we scratch all of these and implement one new system. (...) It's better to go for some system which are off the shelf and then slightly adjust on that to your your needs."	"Qualified people, for sure. That is something the shipping industry is struggling with. And of course, the oil for the offshore oil and gas, oil prices are really hurting."	"streamline the organization, to make sure that everyone does the right things and not do a lot outside and also, to be cost effective, to have systems in place to to make it very, less demand on people."

Source: the author, from NVivo, 2017.

Table 16: Supporters Perception Framework – Resources and similar

	3. Resources	4. Challenges	5. Improvements
Support 1	"Very important (…) if the innovation will give us anything back, it will save us money or just for the board (to see)."	"operating in remote areas a lot.. Africa, Faulkland islands (...) everything takes time."	"we are developing our own lot of our own systems."
Support 2	"the most feasible to do what they have to do in the minimum prices possible so it will be a price that will lead the market to go with these new technologies or not."	"Oil prices... Actually, the marketplace is starting to get better. But it's still very very hard."	"if you have a good database of good softwares and good system that actually makes the processes running in a much better way then it's definitely a good advantage for the for the industry."
Support 3	"it's very important. Everybody is going to ask "why". So, as long as you can justify the investment, it's fine. The main thing now with this situation is, if you can demonstrate that you will save money, they might be ok with doing something new."	"The main challenge is that after this downturn in the industry, with the low oil price... Even though now is going higher, going back on, the investors, the oil companies are very reluctant to invest again."	"very focused on the technical part and how we do the installation (…) you have the focus on having the best technology for installing their products subsea."

Source: the author, from NVivo, 2017.

Table 17: Operators Framework - Others

	6. Audits	7. Corruption
Opperator 1	"Every year, every month on the units. Because we have to cover all the fleets, by the ISO standard, the ISM code. So it's an ongoing process where we, go every year and we also do it on our external ganders."	"It's a risk but it's not a problem for our company."
Opperator 2	"not an issue, as it follows IMS, DNV, IMO and have already all the bases set/follow all guidelines."	"not viewed as a main problem as the company has guidelines/trainings on preventing it, but systems could improve results and avoid problems."
Opperator 3	"there are a lot of audits, we have a plan, other the plan. We are living and I think we are on (audits)... For each vessel we need at least three, four, five audits during the year. We have an extra sheet so we put all the audits in, and the dates."	"Yes, it has to be (one challenge). We have been in cases, especially from your country, sorry." (Brasil)
Opperator 4	"there are requirements so you are not coming away (from) this clause and internal audits and, all this stuff. (…) It is something which is built in already into the cost and it's done easily, it's not anything that obstruct the flow, no."	"In some countries definitely yes (is a problem). It is a challenge for them to say no, meaning that they might lose towards the one who says yes and doesn't care."

Source: the author, from NVivo, 2017.

Table 18: Supporters Framework – Others

	6. Audits	7. Corruption
Support 1	"We have all the financial audits, that's one thing of the company itself. We have class audits annually. (...) we have flag state audits annually. (...) And then we have, usually before every project."	"We are extremely afraid of it, of course. We don't want to be included into any corruption scandal or whatsoever so, they demand, the top management here is focusing a lot on it."
Support 2	"it's not a problem, part of the normal business."	"I don't think it's a problem and I don't think they invest in or are very much worried about it, actually.."
Support 3	"the cost of audits are not too high anymore, I would say. Because you're so used to doing it that you don't invest too much money on it.. It's part of your overhead, almost."	"they are quite strict with the compliance. (…) But, it is a complicated thing. It takes time, takes a lot of training. So, it's a big department they have just to keep things in line."

Source: the author, from NVivo, 2017.

Table 19: Operators Framework - Comments

	8. Comments
Opperator 1	"we rely much more on Big Data. (...) This will be one of the future investment areas for the maritime industry. You have an opportunity to get to our big data and block chain will further prove that." "Cost is one (factor for considering Blockchain) and the other one is maybe that the suppliers don't use it. I don't know if that's a challenge. So the whole supply chain has to use it for it to be successful."
Opperator 2	"For a smaller company, technology is important, but people knowledge might be more important." "Is the system enough? Is it what the people (workers) need/want? How much money/resources is it necessary for training? Is this higher than the costs of installing the technology? Will it cover/supply all areas? If not, will it integrate with the other systems in place?"
Opperator 3	"The cost is the main driver for the moment - the main driver and the main challenge to everything."
Opperator 4	"everything is developing faster and the maritime industry has to in a way, follow this if not, they will be out." "Qualified people (...) That is something the shipping industry is struggling with. And of course, the oil for the offshore oil and gas, oil prices are really hurting, off course."

Source: the author, from NVivo, 2017.

Table 20: Supporters Framework – Comments

	8. Comments
Support 1	"if we didn't believe that research was important then we would have shut it down completely. Because this is not giving us any value today, this is giving a value maybe five, ten years from now. But still we believe so much in it, that it's still consuming a lot of money."
Support 2	"I've been working with offshoring engineering for more than 10 years and it's all about cost. So it's a cost that leads the company/" "I want to see something proved in my market and in the other side, as a project manager (...). So if you see that is proved somewhere and then of course someone can give me good points mentioning that this is applicable for your process then. OK. You know, I would give a try. Sure."
Support 3	"I'd like to see more innovation. I want to see more and more ways to work and, when you read the news or read about how other companies are working and then you see the way you work you think: "OK we're like 20 years behind". Even though you get great success and great projects and you do very cool stuff. You do stuff 3000 meters underwater and stuff doing all kinds of things subsea. But when you do everyday work in a very old way... It's difficult."

Source: the author, from NVivo, 2017.

A word frequency query was performed to search for the 100 most frequent words in both sets of data – Operators and Supporters, grouping the results with stemmed words and synonyms, sorting the results by weighted percentage in text. It was excluded specializations and generalizations, allowing seeing more clearly the most common words coded by source, thus, emphasizing such similarities and differences from the interviews' results. Tables 20 and 21 below shows the most significant results of both groups, being the top weighted words (above 0.88% in text) including some of the grouping words as example. In addition, a cluster analysis of the 10 most frequent words from both groups was performed to illustrate the similarities and differences afore mentioned, showed in graphics 3 and 4 below, allowing a 3D view.

Table 21: Word Frequency Query - Operators

Word	Count	Weighted %	Similar Words
think	144	1,34	believe, consider, guess, mean, meaning, means, reason, reasonable
going	166	1,32	become, department, move, operation, start, work
need	119	1,26	ask, demand, involved, requirement, want
actually	89	1,25	genuine, realized, really
cost	96	1,23	cost, costing, costly, costs, price, prices, pricing
see	160	1,21	check, consider, control, experience, realized, watch
company	82	1,11	companies, company, parties, party, societies, society
just	113	1,03	exactly, good, hard, just, right
technology	69	0,95	engineer, engineering, technical, technological
like	72	0,89	care, compare, compared, correspondence, potential, probably
industry	63	0,88	industrie, industries, industry

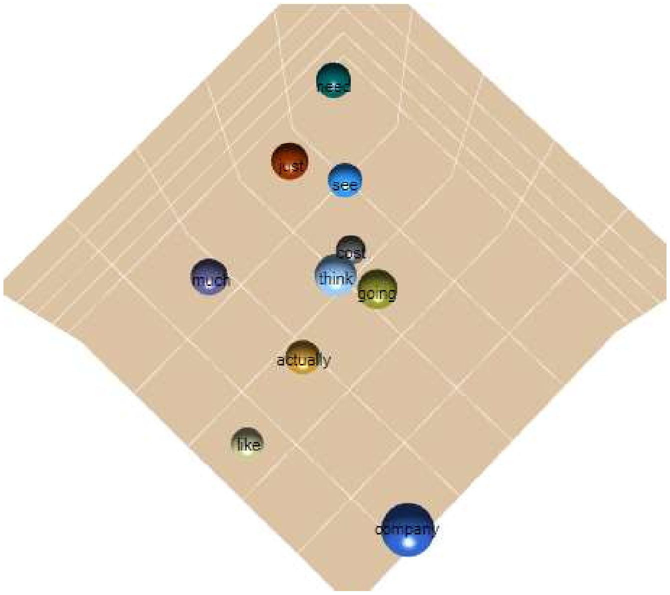
Source: the author, from NVivo, 2017.

Table 22: Word Frequency Query - Supporters

Word	Count	Weighted %	Similar Words
company	114	2,12	companies, company, parties, party, societies, society
think	115	1,53	believe, consider, guess, mean, meaning, means, reason, reasonable
work	127	1,47	make, operate, operation, process, solve, turn
much	87	1,39	lot, often, practice
like	76	1,32	care, compare, compared, correspondence, potential, probably
just	98	1,3	exactly, fairly, good, hard, justify, right
actually	63	1,19	genuine, realized, really
get	142	1,12	acquire, bring, come, contract, develop, experience, find, grow, start
now	56	1,01	directly, nowadays, present, today
see	95	1,00	check, consider, control, experience, realized, watch
need	77	0,99	ask, demand, involved, requirement, want
technology	57	0,98	engineer, engineering, technical, technological

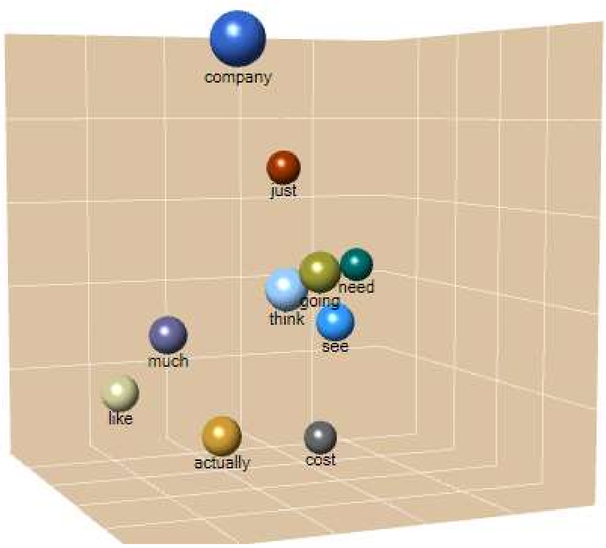
Source: the author, from NVivo, 2017.

Graph 3: Top 10 Most Frequent Words Cluster Analysis Top View



Source: the author, from NVivo, 2017.

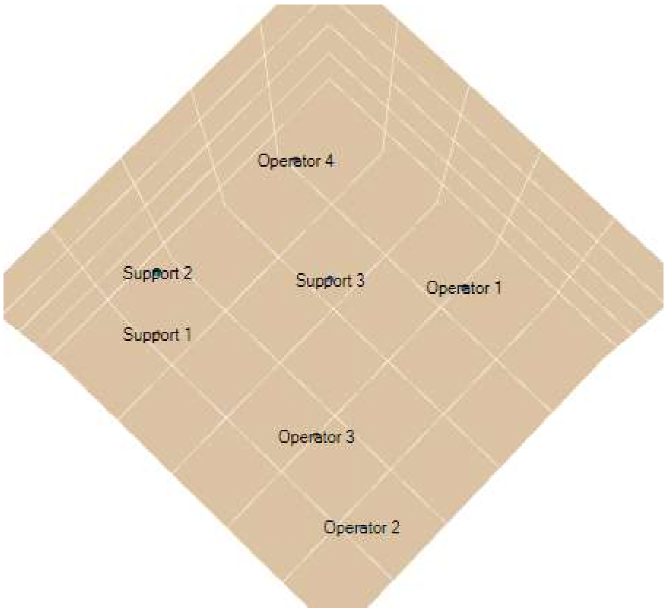
Graph 4: Top 10 Most Frequent Words Cluster Analysis Front View



Source: the author, from NVivo, 2017.

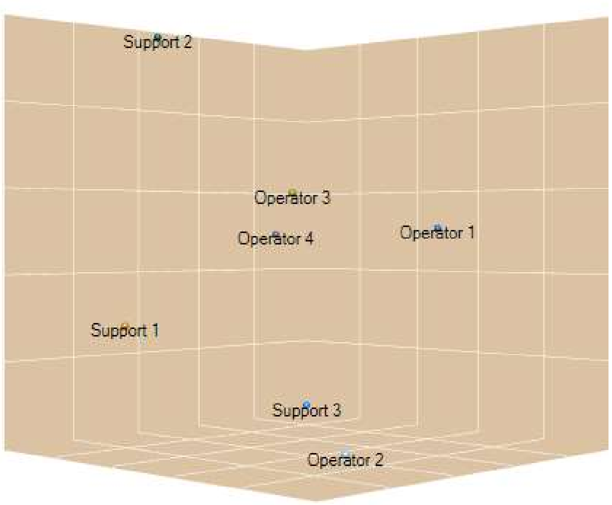
Finally, a three-dimension cluster analysis was performed based on Jaccard's coefficient to analyze the sources by coding similarity, which is shown in graphs 5 and 6 below, being the first a view from the top and the second a frontal view, allowing the 3D visibility. The average Jaccard's coefficient for all sources analysis resulted on 84,9%, a high level of similarity. The key interviewee to reduce this level was "Operator 2", as seen on the different replies, mostly regarding technology.

Graph 5: Cluster Analysis Top View



Source: the author, from NVivo, 2017.

Graph 6: Cluster Analysis Front View



Source: the author, from NVivo, 2017.

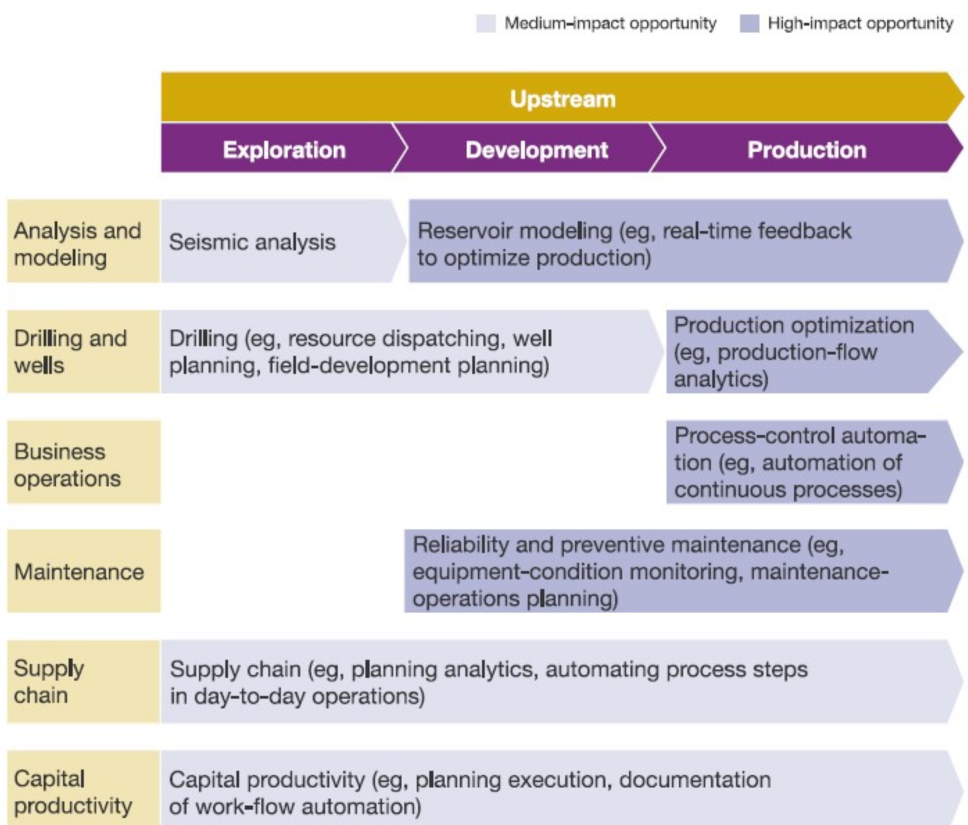
4 DISCUSSION

4.1 The possibilities for Blockchain Technology and Positive Aspects

The timing for offshore seems right for innovation, in particular for Norway, which is a big player in the offshore industry, being traditionally a maritime nation and a maritime cluster. In 2014, the Norwegian maritime industry accounted for around 6.7% of the country's GDP with the shipping, maritime equipment supply and shipbuilding sectors representing 3.9%, 1.2% and 0.3%, respectively, and represented 4% of the country's labor force. However, because of the weaker offshore market, its number of employees has had a decrease of 10% in 2015 (OECD, 2016). The country offers great support for the industry, as it is the government's ambition to assist Norway into becoming one of the leading maritime nations. Therefore, the government works closely to the industry to drive towards such goals, in addition to supporting research and development and policies to assist driving towards an environmentally friendly fleet (OECD, 2016). As Norway has higher labor costs than most maritime countries and higher than average costs for the maritime market (Norsk Industri, 2015), the country needs to invest in high value-added sectors and create value from knowledge. The government's assistance towards research and development is key into allowing and fostering innovations in the field, representing the cultural change cited by Stopford on his interview to Splash 247, mentioned on item 2.3 before. Such cultural change might begin from an innovation perception and adoption within the industry. It is easier to adopt an innovation when other peers have done so, as it is also easier to foster its adoption within the company as well. Rogers (1995) says that most individuals evaluate an innovation based on the subjective evaluations of near-peers who have adopted it rather than on the experts' scientific research. Therefore, these near-peers serve as role models whose behavior tends to influence others. The collected data confirms such phenomena, as all of the interviewees affirmed being easier to adopt an innovation when other companies have already tested it, both being from inside or outside the field. The individuals added that, by having someone else already taking the lead and proving the technology effective assists on selling the innovation to the upper management, as well as provides information to do so. It is also a good case for non-adoption regarding costs and in case of failure and ineffectiveness.

There are several opportunities within the industry for digital innovation. Martinotti et al. (2014) measured the impact of automation opportunities in the upstream industry (oil and gas exploring), showed in Figure 12 below.

Figure 12: Impact of Automation Opportunities in the Upstream



Source: Martinotti et al, 2014, McKinsey analysis.

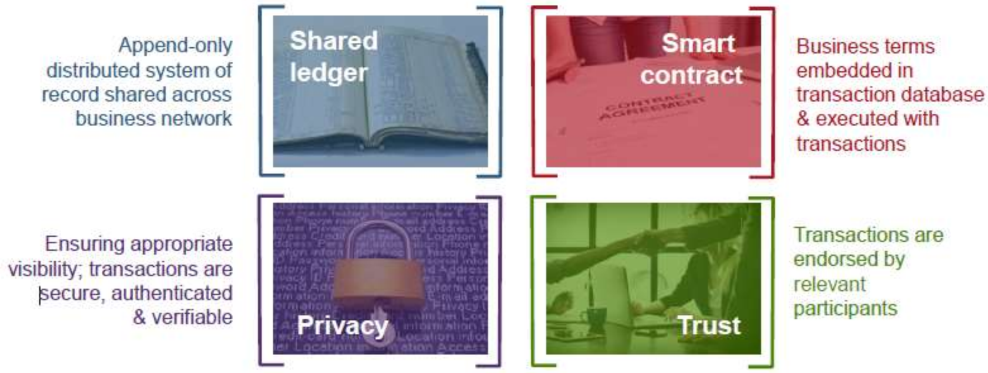
Martinotti's findings shows that the majority of high-impact opportunities are in the later stages of development and production, separated throughout the chain. This research's collected data supports the idea that the biggest opportunity for Blockchain application lies in securely connecting each step in order to optimize the chain as a whole and create value from it, also corroborated by IBM's Institute for Business Value Analysis, shown in Figure 13 as follows.

Figure 13: Three Ways Enterprises Benefit from Blockchains

Source: IBM Institute for Business Value Analysis, 2016.

At the same time, supply chain is passing through a revolution, highlighted before. Internet of Things should connect devices to suppliers anticipating demands and creating useful data from it. Blockchain's applicability to this architecture (shown in Figure 14) allows companies to keep an encrypted, immutable ledger of transactions, which can be shared trustfully within the selected network due to the peer-to-peer (P2P) proof of work concept, eliminating the third parties involved, thus saving money through reducing costs.

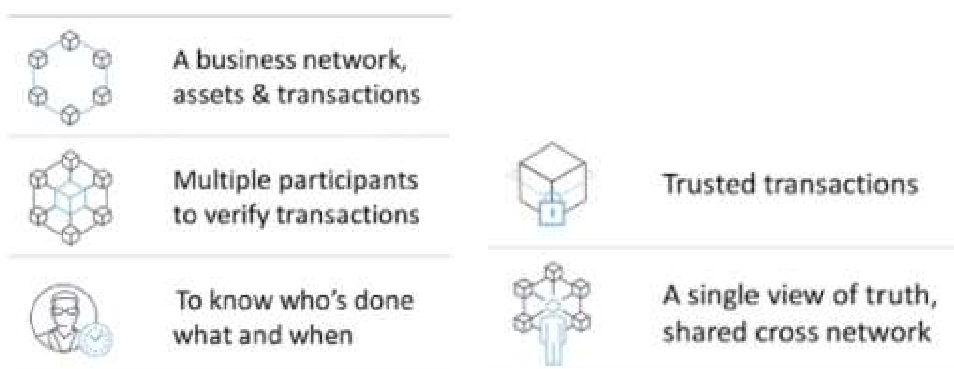
Figure 14: Blockchain for Business Applicability



Source: IBM Corporation, 2017.

This integration also supports applying collected data to follow assets live, having real time notion and reminder coming from components in the chain or even in the assets themselves, such as vessels parts that require changing or maintenance. However, it is important to highlight that Blockchain does not replace database software nor is a distributed database replacement; data analysis tools; is not needed if there is no business network and more importantly, it does not replace transactional processing systems. It can transform these systems, yet only when one or more of the criteria shown in figure 15 are met (IBM, 2017, URL).

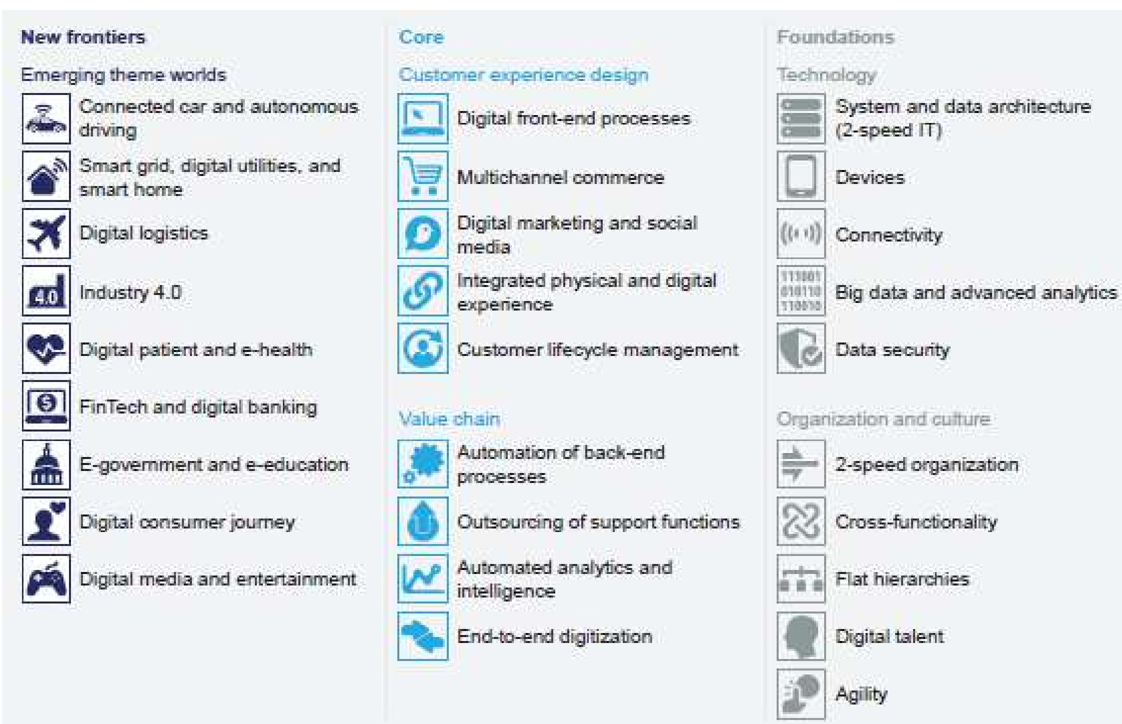
Figure 15: Why Applying Blockchain



Source: IBM Government Industry Blog, 2017, URL.

However, simply applying a technology, digitalization and/or automation without further evaluating where it would provide most benefits does not benefit any industry or company. McKinsey (2015) report argues that an enterprise mainly has three relevant fields of action to act in order to proceed with digitalization or to examine further into, deciding the next steps, showed in Figure 16 below. It explains that digitalizing the core, end-to-end daily processes by increasing automation, connectivity and databased decision-making unlocks revenue, cost potential and prepare the company to the "new frontiers" field; which addresses new risks and opportunities presented by digitalization. Companies can decide whether they want to be pioneers, wait for the market and react to it, or to withdraw from it into a specific niche. Furthermore, reinforcing foundations enable digitalization in scale while IT systems need to adapt its operational model, allowing a scalable next-generation infrastructure focused on cyber security as well (McKinsey, 2015).

Figure 16: Three Relevant Fields of Action Across the Digital Enterprise



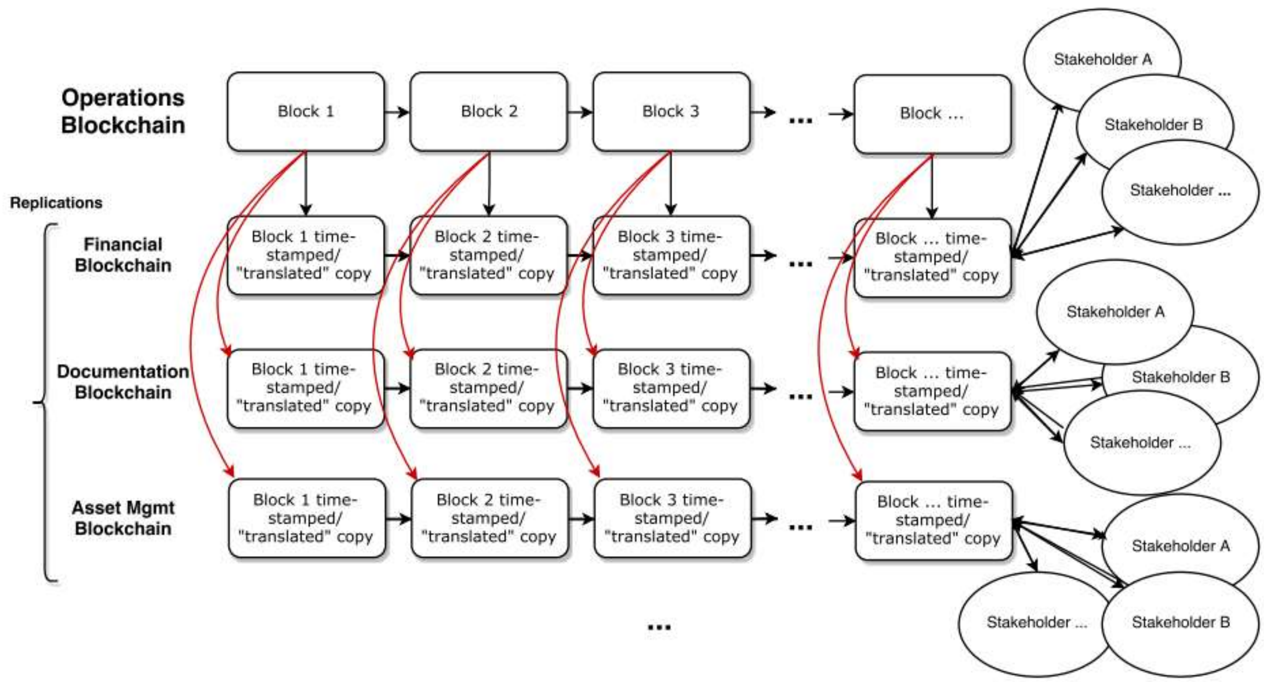
Source: McKinsey, 2015

The results from analyzing the interviews shows that there is need to innovate in the Maritime Industry and consensus regarding such need, however, with many limitations and uncertainties. There is also a consensus that costs are the main enabler and barrier to technological implementation, as well as secondary costs derived by it, such as reliance on consultants and third parties, need for training, need for specific personal and other possible requirements, such as software integrations. The willingness for innovation is directly connected to these factors, as well as what can be expected from the innovation. Again, the great measurement for success is cost, being cost reduction the biggest motivation for innovation. Interesting facts derive from the fact that all interviewees ranged from 28 to 45 years old with the least experienced one with more than five years in the industry and the most experienced one with more than 20 years. While the younger ones presented themselves as more keen to embracing innovation, the older ones transferred the responsibility to the new generations to come. The technology was better received within those from innovative companies, which already come from a culture of innovation, however, the lack of knowledge about the technology was a barrier to its perception, as six out of seven interviewees declared that had close to none information about the technology or confused it with Bitcoin. After briefly introduced to the technology, the main interest over it came from the possibility of applying it to enhance data security, transparency, communication, and legislation compliance. The lack of interest over audit procedures enhancement also appeared as an interesting fact, as six out of seven interviewees named audits as almost part of the cost of overhead, thus, expecting that everyone will just work with them since they cannot be dismissed. Therefore, they failed to see the improvements that could happen and costs savings from them, even if smaller than the bigger cost-saving drivers. More than half of the interviewees mentioned the possible use for documentation and maintenance tracking, assisting process improvements for daily operations, however, only two considered corruption as a challenge, failing to see how both can be connected and enhanced by Blockchain application. It allows an easy way to keep track and prove possible changes, upgrades, deployments, which can be used for legislation purposes, such as port authorities and state control compliance, among others already mentioned in this study. In addition, it enhances economy by allowing a fast and agile supply chain, as all registers in one place accessible to all parts. Therefore, it allows keeping track of materials used in building and maintenance, proving all steps and changes and what has been used, replaced, when, how and by whom, without the possibility of data tampering and proving any attempts to do so. This way, it helps audits, facilitate port and class inspections and compliance to IMO and other legislation. In all the cases afore mentioned, the applications exclude the need for intermediaries, such as audit companies. Yet, if a company still rather trust a third party validation, the Blockchain application can reduce significantly the amount of work and hours required, hence, reducing costs. It also provides great documentation ledger for second-hand purchases, scrap market and insurance policies and claims. The facts that Blockchain is an immutable ledger, real-time stamped by transaction, it assists preventing frauds and cyberattacks.

Still, some tech-enthusiasts claims that Blockchain needs a “killer app” to broaden its applicability, something like the web browsers, which allowed the internet to be useful. While there is no such thing, a great number of start-ups are developing SaaS (software as a service) applications to enhance the use of Blockchain. However, most of these end up being useless, as they try to centralize what is meant to be a community shared ledger, even if permissioned. Vitalik Buterin, the co-founder of Ethereum (another cryptocurrency and Blockchain network enabler) says, *“there is no killer app, but there is a list of long-tail applications for just about every kind of software imaginable”* (Buterin, V., n.d). This could mean that the possible best application for Blockchain is in its combination with several other technologies, software and tools, already available or yet to come, extracting the best of each to proportionate the best solution to the business model as required.

The difficulty to benchmark achieved results acts as another barrier, as the main difficulty in perceiving such possibilities comes from the lack of measurements for Blockchain application, especially inside the industry. This paper's author attempted to do so, failing to obtain the necessary in-company information to succeed. However, the author developed the Processes Blockchain Framework, generating a basic operation's blueprint proposal with a "fingerprint" that cannot be altered, showed on figure 17 in the sequence.

Figure 17: Processes Blockchain Framework



Source: The author, 2017.

This framework proposes several basic chain pipelines, flexible to adapt to several different uses while following the same concept. The operations steps would generate a block with a hash, connecting in one main Blockchain, which would have time-stamped copies in real-time, however, its content would be "translated" to another information related to the operations, such as financial information, asset management data, documentation and certification for audits, vendors and customers and other possible pipelines. These would work based on the double-booking accounting system, only in this case with several record entries, as a third, fourth and so on, pertinent to each block. Then, only the required stakeholders would gain permission to access its relative Blockchain, thus protecting information while making it accessible to the parties that need so, controlled by the company in charge of it. As a theory concept still not in application, it does not have a measuring model, which could be developed in further studies, by attempting to create and deploy the framework on an open-source code platform, then developing a more complex structure to apply to case studies with a relative lower cost than creating coding from scratch. Still, this model might require extra technology to make it possible, such as to enable the information "translation" from the main ledger to its replications, which also requires further studies. Ideally, it would then connect to other technologies, such as IoT for asset management, data for Digital Twins and AI learning and others, creating a sustainable supply chain.

4.2 Blockchain General Constrains and Setbacks

From a technical perspective, Blockchain can be quite complex for most everyday users, proposing a barrier for its adoption. People require training and each one goes on its own learning curve, which can take a toll on a new system, tool, process or software adoption. It is required to either develop in-house training or outsource them, both requiring resources to fulfil. Still, there will be required to have IT support for the technology and the people using it, which implies in more costs. Even if the company tailors a technology to adjust it to the company's needs, the company will be dependant of IT consulting and support, which is proven to be very expensive, stressful and therefore, something most companies want to be away from. Furthermore, companies already have developed and operational systems in place, which would need to integrate to the technology if they were to be retained within the company. This would facilitate user adoption, as the easier the new IT system integrates to the retained software, the greater are the chances of the organization realizing benefits from the new technology (Tornatzky and Klein, 1982). Moreover, the more compatible the new systems and the remaining software are, the more satisfied will the users be (Delone and McLean, 1992). Even if not all systems need to be replaced, integrated or adopted throughout the whole company and/or industry, other concerns emerge from being more connected every day.

The main driver for any technology or innovation adoption is cost, being both negative and positive. As mentioned before, all the interviewees highlighted the costs' toll on their everyday operations and decisions as well as its role into being effective and competitive. The afore mentioned Blockchain free options might not fulfil the corporative needs, while the ones more suitable for such use can signify an additional fee and weight to companies. In addition, cyber security has become a threat and concern to the whole industry, which acknowledges that the benefits of the oil and gas industry digitalization are enormous, but remind that they bring cyber risks along as in 2016, almost 68% of oil and gas companies were affected by at least one significant cyber incident (Aberdeen Group, 2017, URL).

Some problems have arisen from Blockchain's early phases of research, development and implementation. Some examples are the case of DAO, an organization built based on smart contracts, which reported having been stolen by over 60 million USD through a code breach exploit; while another company, Bitfinex, reported the same for about 70 million USD due to a flaw in private keys storage (Hernaes, 2017, URL). It is not certain whether such cases could have been avoided, but the technology still has a lot of ground to grow, and many developments are being researched, implemented and discovered, which can represent great possibilities in the future, while also helping to turn challenges into opportunities. Blockchain can be a solution to defend important transactions and have other applications disclosed in this study, as it can also be a target, therefore, requiring IT experts and consultants to assist preventing threats and a good development team or company, which will represent costs for its implementation. Nevertheless, it is important to remember though that the Blockchain technology is not yet completely mature, as the technology started to be looked at separately from Bitcoin around 2014 (IBM, 2017, URL).

5 CONCLUSION AND PROPOSITIONS FOR FUTURE RESEARCH

5.1 Conclusion

This study came from the perception that the industry lacks innovation in its operations and supply chain, being one of the late adopters regarding new technology unrelated to drilling, productivity enhancement or safety. The main research question driving this study attempted to foster an academic research of the topic, which is in high repercussion among the main technological and consulting firms in the world. The answer to this question - Why should the offshore business implement the Blockchain technology to connect its Supply Chain – is quite simple. The industry needs to reduce costs to be able to remain lucrative and overcome the obstacles presented by global energy supply and demand, turning them into opportunities, while complying with the legislation requirements enforced by the responsible global regulation bodies. In addition, it requires an enhanced action against cybercrimes and piracy. Thus, the technology presents itself as a solution for such and opens many more opportunities within the industry.

Still, the industry needs a push towards the digital revolution it requires – external motivation. Based on the literature review and the results, it is clear that the industry is motivated by costs and by the need of implementing something based on legal requirements. Just as in the case of the Port of Rotterdam, if required by the Port Authority, Classification Societies, IMO or other similar bureaus, the industry rushes to adapt itself in an attempt to "future proof" its assets, which could be a main enabler for innovation and technological implementation. It is clear that the industry's lack of knowledge of Blockchain's possibilities is the principal reason for its still rather slow adoption rate, which should change in the near future, based on the success of the pioneer's adoption, mentioned on item 2.5.

A second research question followed the one mentioned afore, being - Which are the main advantages and limitations of its application?

The technology has a broad range of applicability, allowing connecting the supply chain more efficiently, providing the exchange and visibility of time-stamped proofed data, decreasing the industry operational costs with intermediaries and increasing security. It also allows full visibility for all parties involved with proof of work, facilitating Class Societies inspections, Port State Control and audits compliance. However, it is not enough to solve the operations need for innovator. It is important to differentiate the technology in order to engage with it, highlighting that it is not a data analytics software, a data storage provider nor server. Yet, it does best on what it promises – creates and provides decentralized public or controlled access to a ledger, which is immutable, secure and time-stamped verified by proof of work hash-system that allows the elimination of third parties and the costs associated to it. However, the lack of knowledge about the technology and the industry's cultural barrier to innovation act against innovation and new technology application, even though the results showed a consensus on the industry's need for enhancements for both. Nevertheless, the results also showed that studies and cases on Blockchain application in other fields increase the industry willingness to its application on the Maritime industry, while having Blockchain implementation specialized third parties would increase the implementation possibility and the industry willingness due to reduced costs and friction. Costs presented itself as the key driver to allow innovation, as both enabler and barrier, being the factor that can boost the industry's willingness of Blockchain application, especially regarding operations, in addition to the industry's need for technological innovations. The results lead to the author's proposed framework for the Processes Blockchain, creating a basic operation's blueprint proposal with a "fingerprint" that cannot be tampered. The framework proposes a basic chain pipeline, which can be altered to adapt to several different uses, still following the same concept. As a theory concept still not in application, it does not have a measuring model, which could be developed in further studies.

5.2 Propositions for future research

This research developed from the perception that the Maritime Industry lacks innovation and technology application when connecting its supply chain. Since the industry has been struggling with achieving profits, cost reduction is the focus to achieve such goals and better yet, survive in tough market conditions. After researching and analyzing all collected data, it was possible to formulate the following proposition for further studies:

- Research the possibility of integrating Blockchain, Internet of Things and Digital Twin technologies and its application to the Maritime Industry – create framework for applications and methodology for measurement.
- Work with a company applying Blockchain (Case Study) and evaluate the steps/results, proposing success measurements for Blockchain application within the industry and providing benchmark for other applications, while testing this study's proposed framework in parallel.
- Develop a case study about Blockchain in the Maritime Industry for legislation purposes and compliance (IMO, Port State Control, Class Societies, etc.) - evaluate the steps/results and propose a framework for application.
- Study the differences among the Types of Blockchain and their pro and cons within the industry – develop the possibility of applying open source/free Blockchain.

6 RESEARCH LIMITATIONS

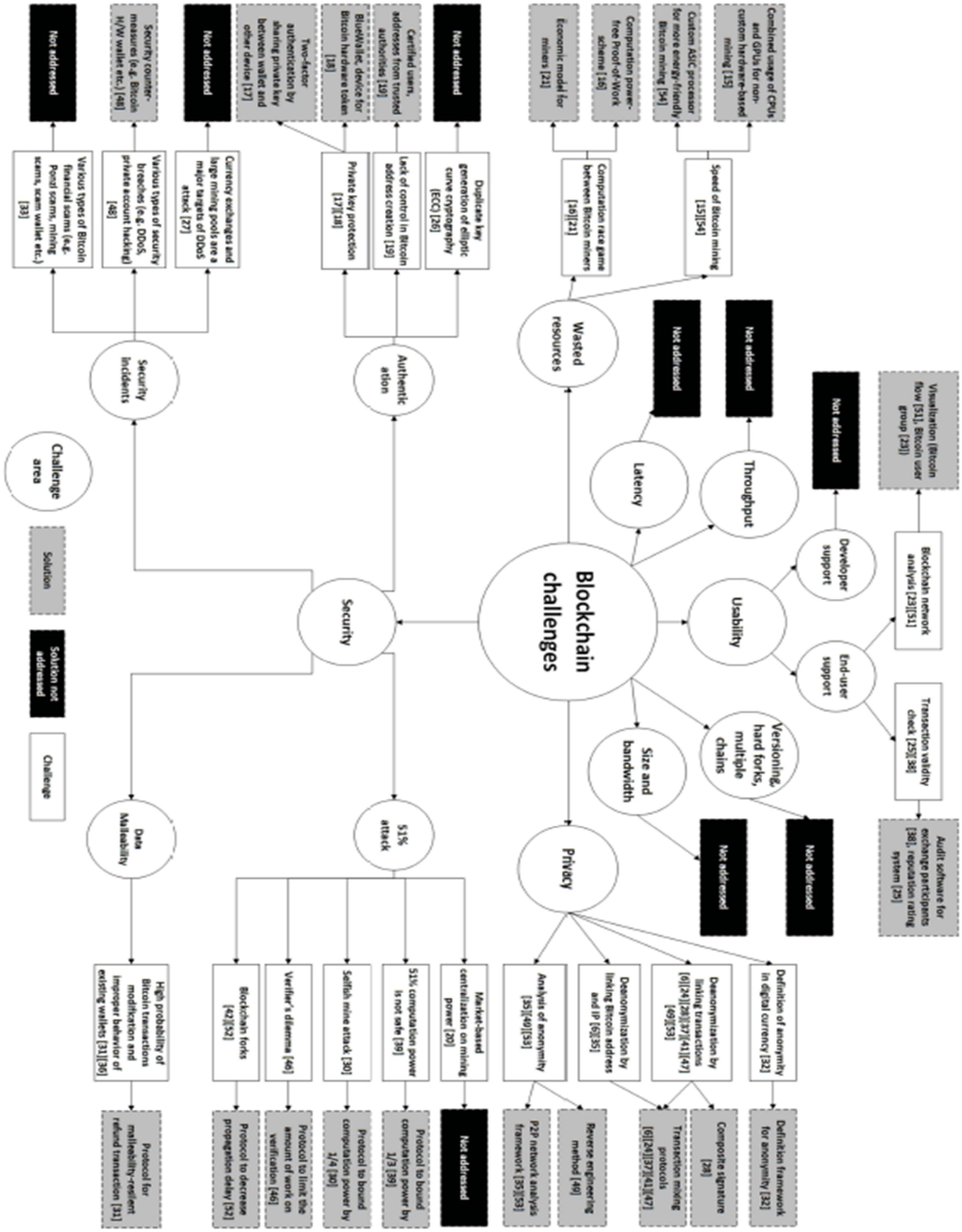
The main limitations this research has faced was to have important and interesting interviews performed within the main offshore companies in Norway. Being a foreign student without a pre-established network had been a great challenge. However, it was possible to accomplish the number of people pre-established by connecting with HSN colleagues that I had developed a network with and by talking to some friends who work in supporting the Offshore industry. Some of the contacts were interviewed themselves, other had contacted someone they had in their network and allowed the interviews to happen. This shows the importance of network within academia and the industry to facilitate research.

A second large limitation was to find relevant published academic researches only about Blockchain usability and challenges, excluding its application on Bitcoin. The systematic review on Blockchain Technology publications by Yii-Huumo *et al* (2016) mapped such studies and summarized the studies about the Blockchain challenges and solutions (Figure 18, page 71). No relevant academic publication disclosed the maritime field and Blockchain in any ways. In addition, the number of publishers also increased considerably, as the technology was considered hype once more companies began adapting to it. The newness of the technology applicability itself increased the number of poorly written articles, with limited information or dubious sources.

The third main limitation is to segregate the maritime industry in order to show specific functionalities and applicability. Exploration, production, supply chain is more unified with modals combinations and integrations, with a booming number of software companies dominating information. Most of such information comes then from published researches, companies' websites and the data collection interviews, which presents its own challenges mentioned before.

The newness of the technology also shows very little benchmarking information, as there is very few information about its application to the shipping and offshore industry. At the same time, this became the opportunity of showing something new to the industry through this research.

Figure 18: Summary of the Identified Challenges and Solutions of Blockchain



Source: Yii-Huumo *et al*, 2016, p. 20.

7 REFERENCES

Anderson, M., Edgar, D., Grant, K. (2014). *Innovation Support in Latin America and Europe*: Theory, Practice and Policy in Innovation and Innovation Systems. Routledge.

Arlbjørn, J.S., deHaas, H., Munksgaard, K.B. (2011). *Exploring supply chain innovation*. Logist.Res.3, 3–18.

Ball, B. (2016). *Reducing Global Logistics Cost with Benchmarking and Shipping Container Pricing Transparency.* Aberdeen Group.

Blockchain Hub (2017). *Blockchains and Distributed Ledger Technologies*. Retrieved from: https://blockchainhub.net/blockchains-and-distributed-ledger-technologies-in-general/

Blockchain Technologies (2016). *Blockchain Applications. What are Blockchain Technology Applications and Use Cases?* Retrieved from: http://www.blockchaintechnologies.com/blockchain-applications

Brave New Coin (2016). *Blockchain Tech companies focus on the $40 trillion Supply Chain Market*. Retrieved from: https://bravenewcoin.com/news/blockchain-tech-companies-focus-on-the-40-trillion-supply-chain-market/

Bryman, A. (2012). *Social research methods*. Oxford: Oxford University Press.

Bryman, A., Bell, E. (2015). *Business Research Methods*, 4th Ed. Oxford: Oxford University Press.

Burke, J. (2017). *99% of Blockchain Startups Are Bullshit.* Outlier Ventures & Convergence VC. Retrieved from: https://www.linkedin.com/pulse/99-blockchain-startups-bullshit-jamie-burke/

Buterin, V. (2017). *The Meaning of Decentralization.* Retrieved from: https://medium.com/@VitalikButerin/the-meaning-of-decentralization-a0c92b76a274

CB Insights (2017). *Banking Is Only The Beginning: 30 Big Industries Blockchain Could Transform.* Retrieved from: https://www.cbinsights.com/research/industries-disrupted-blockchain/

Choudhry, H., Mohammad, A., Tan, K.T., Ward, R., (2016). *The next frontier for digital technologies in oil and gas*. Retrieved from: http://www.mckinsey.com/industries/oil-and-gas/our-insights/the-next-frontier-for-digital-technologies-in-oiland-gas.

Coin Desk (2017). *World's Largest Shipping The World's Largest Shipping Firm Now Tracks Cargo on Blockchain*. Retrieved from: https://www.coindesk.com/worlds-largest-shipping-company-tracking-cargo-blockchain/

Cooper, D., Schindler, P. (2011). *Business research methods*. New York: McGraw-Hill/Irwin.

Creswell, J. (2012). *Educational research*: planning, conducting, and evaluating quantitative and qualitative research. Boston: Pearson.

Creswell, J. W., Miller, D. L. (2000). *Determining validity in qualitative inquiry*. Theory into Practice, 39 (3).

Decker, R., Flaaen, A., Tito, M. (2016). *Unraveling the Oil Conundrum*: Productivity

Deffeyes, K.S. (2001). *Hubbert's Peak: The Impending World Oil Shortage*. Princeton University Press, Princeton NJ.

Delone, W. R., McLean, E. R. (1992). *Information systems success: the quest for the dependent variable.* Information Systems Res.; 3(1), 60–95.

Demirbas, A., Bafail, A., Nizami, A. S. (2016). *Heavy oil upgrading: unlocking the future fuel supply*. J. Pet. Sci. Technol. 34 (4), 303–308.

Den Norske Veritas - DNV GL (2014). *Alternative Fuels from Shipping*. Strategic Research & Innovation Position - Paper 1.

Den Norske Veritas - DNV GL (2016). *Making your Asset Smarter with the Digital Twin*. Retrieved from: https://www.dnvgl.com/article/making-your-asset-smarter-with-the-digital-twin-63328

Dhanji, T. (2017). *Blockchain – Where Oil and Gas Traders Dare to Trade*. Ernest Young Publications. Retrieved from: https://www.linkedin.com/pulse/blockchain-where-oil-gas-traders-dare-tread-talib-dhanji

Drucker, P. (1964). *Managing for Results*. New York: Harper & Row Publishers.

Elatab, M. (2016). *Five Trends in Oil & Gas Technology, and Why You Should Care*. Retrieved from: http://venturebeat.com/2012/03/28/5-trends-in-oil-gas-technologyand-why-you-should-care/

Energy Information Administration (2011). *International Energy Outlook*, US DOE.

Eniram (2017). *Starting your Voyage towards the New World of Marine Digitalization*. Eniram White Paper.

Finextra (2016). *Marine Transport International Applies Blockchain to Shipping Supply Chain.* Retrieved from: https://www.finextra.com/pressarticle/66223/marine-transport-international-applies-blockchain-to-shipping-supply-chain

Flint, D.J., Larsson, E., Gammelgaard, B., Mentzer, J.T. (2005). *Logistics Innovation: a customer value oriented social process.* J. Bus. Logist. 26, 113–147.

Hahn, G. J., Packowski, J. (2015). *A perspective on applications of in-memory analytics in supply chain management.* Decis. Support Syst. 76, 45–52. http://dx.doi.org/10.1016/j.dss.2015.01.003.

Hassani, H., Silva, E. S., Al-Kaabi, A. M. (2017). *The role of innovation and technology in sustaining the petroleum and petrochemical industry.* Technological Forecasting & Social Change 119 (2017) 1–17, Elsevier.

Hernaes (2017). *Blockchain – Hype or Reality?* Retrieved from: http://hernaes.com/2017/04/24/blockchain-hype-or-reality/

Hoffmann, J., Kumar, S. (2010). *International Seaborne Trade – Globalization, the maritime nexus*. The Handbook of Maritime Economic and Business.

IBM (2017). *Ten Things Blockchain is not.* Retrieved from: https://www.ibm.com/blogs/insights-on-business/government/ten-things-blockchain-not/

Improvements and Cost Declines in the U.S. Shale Oil Industry. Feds Notes. Retrieved from: https://www.federalreserve.gov/econresdata/notes/feds-notes/2016/unraveling-the-oil-conundrum-productivity-improvements-and-costdeclines-in-the-us-shale-oil-industry-20160322.html.

International Energy Agency (2016). *World energy Outlook 2016.* Retrieved from: http://www.worldenergyoutlook.org/

Kendon, P. (2016). *Five Innovative Technologies Changing Maintenance Management in the Oil and Gas Sector*. Retrieved from: http://www.solufy.com/blog/5-innovativetechnologies-disrupt-maintenance-management

Knect365 Maritime (2017). *Six Maritime Start-ups that are changing the Game.* Retrieved from: https://knect365.com/talentandtraining/article/1149354e-68d9-4e74-9f91-a900ac869526/6-maritime-startups-that-are-changing-the-game

Koc, T., Bozdag, E. (2016). *Measuring the degree of novelty of innovation based on Porter's value chain approach.* European Journal of Operational Research 257 (2017) 559–567, Elsevier.

Krabbe, M. (2007) *Leverage supply chain innovation.* Ind. Eng. 39, 26 –30.

Lacey, M., Lisachuk, H., Giannopoulos, A., Ogura, A. (2015). *Shipping smarter: IoT opportunities in transport and logistics. The Internet of Things in shipping*. Dupress-Deloitte.

Lincoln, Y. S., Guba, E. G. (1985). *Naturalistic inquiry*. Beverly Hills, CA: Sage.

Lloyds Register Marine, University College London (2014). *Maritime Fuel Trends*. Retrieved from http://www.lr.org/en/_images/21334172_global_marine_fuel_trends_2030.pdf

Maersk (2017). *Maersk and IBM Target one of Trade's Biggest Barriers.* Retrieved from: https://www.maersk.com/stories/maersk-and-ibm-target-one-of-trades-biggest-barriers

Marr, B. (2014). *Big Data: 25 Amazing Need-to-know Facts*. Retrieved from: http://smartdatacollective.com/bernardmarr/277731/big-data-25-facts-everyone-needs-know

Martinotti, S., Nolten, J., Steinsbø, J.A. (2014). *Digitizing Oil and Gas Production*. Retrieved from: http://www.mckinsey.com/industries/oil-and-gas/our-insights/digitizing-oil-and-gas-production

McKinsey (2015). *Pathway to Value Creation – A perspective on how transportation and logistics businesses can increase their economic profit.* Travel, Transport & Logistics.

Nachmias, D., Nachmias, C. F. (2008). *Research Methods in the Social Sciences*, 7th Ed. Worth, NY.

Norton, J. (2016). *Blockchain. Easiest Ultimate Guide to Understanding Blockchain*.

Norsk Industri (2015). *Norwegian Maritime Equipment Suppliers 2015* – Key performance indicators and future expectations. Retrieved from http://www.menon.no/wp-content/uploads/28maritime-equipmentsuppliers_2015.pdf.

Norway Exports (2017). *Gas to Become World's Primary Energy Source by 2035*. Retrieved from: http://www.norwayexports.no/sectors/news/gas-to-become-worlds-primary-energy-source-by-2035-/

Norway Exports (2017). *Industry Collaboration Delivers Recommended Practice*. Retrieved from: http://www.norwayexports.no/sectors/news/industry-collaboration-delivers-recommended-practice-on-how-to-fight-cyber-threats-in-the-oil-and-gas-industry-/

Norway News (2017). *World's first test site for autonomous vehicles opens.* Retrieved from: http://www.norwaynews.no/worlds-first-test-site-for-autonomous-vehicles-opens/

Norwegian Innovation Clusters (2015). *Norwegian Clusters 2015* – For the future's innovative industries. Retrieved from: http://www.innovationclusters.no/globalassets/filer/nic/publikasjoner/norwegian-clusters-2015.pdf

OECD (2017). *Peer Review of the Norwegian Shipbuilding Industry*. Retrieved from: http://www.oecd.org/sti/shipbuilding.

Offshore Energy Today (2017). *Meet Onboard, the Maritime Internet of Things*. Retrieved from: http://www.offshoreenergytoday.com/oeec-meet-onboard-the-maritime-internet-of-things/?utm_source=emark&utm_medium=email&utm_campaign=daily-update-offshore-energy-today-2017-10-02&uid=207087

Patton, M. Q. (2002). *Qualitative evaluation and research methods,* 3rd Ed. Thousand Oaks, CA: Sage Publications.

Polatidis, N., Pavlidis, M., Mouratidis, H. (2017). *Cyber-attack path discovery in a dynamic supply chain maritime risk management system.* Computer Standards & Interfaces. Elsevier, UK. http://dx.doi.org/10.1016/j.csi.2017.09.006

Raval, S. (2016). Decentralized Applications, 1st Edition. O'Reilly Media, USA.

Rogers, E. (1995). *Diffusion of innovations*. The Free Press, New York.

Schultz, R. L., Slevin, D. P. (1975). *Implementing operations research/management science.* New York: American Elsevier.

Schumpeter, J. (1934). *The Theory of Economic Development*. Cambridge, MA: Harvard University Press, Ch. 2, 57-94.

Stathakopoulous, C., Cachin, C. (2017). *Threshold Signatures for Blockchain Systems*. Swiss Federal Institute of Technology – IBM Research, Zurich.

Stenbacka, C. (2001). *Qualitative research requires quality concepts of its own.* Management Decision, 39 (7).

Splash 247 (2017). *Dr. Martin Stopford on the Future of Shipping*. Retrieved from: http://splash247.com/dr-martin-stopford-future-shipping/

Stevens, L., Sys, C., Vanelslander, T., Hassel, E. V. (2015). *Is new emission legislation stimulating the implementation of sustainable and energy-efficient maritime technologies?* Research in Transportation Business & Management, volume 17.

Stopford, Martin (2009) *Maritime Economics*, 3rd edition, London.

Tachizawa, E. M., Alvarez-Gil, M. J., Montes-Sancho, M. J. (2015). *How ''smart cities'' will change supply chain management.* Supply Chain Management Int. J. 20, 237–248. http://dx.doi.org/10.1108/SCM-03-2014-0108.

The Economist (2010). The data deluge.

The Economist (2015). *Blockchain – The Next Big Thing. Or is it?* Special Report. Retrieved from: https://www.economist.com/news/special-report/21650295-or-it-next-big-thing

The Innovation Effect – OIW (2017). Retrieved from:

Thompson, Victor A. (1965). *Bureaucracy and Innovation*. Administrative Science Quarterly, (10, 1) 1-20.

Tidd, J., Bessant, J., Pavitt, K. (2005). *Managing Innovation: Integrating Technological, Market and Organizational Change,* 3rd Ed. New York: Wiley & Sons.

Tidey, A. (2015). *Breaking the Cycle? Cost Efficiency in Upstream Oil and Gas.* Retrieved from: https://www.woodmac.com/blog/breaking-the-cycle-cost-efficiencyin-upstream-oil-and-gas/

Tien, J. M. (2015). *Internet of connected ServGoods: considerations, consequences and concerns.* Journal of Systems Sci. Syst. Eng. 24, 130–167. http://dx.doi.org/10.1007/s11518-015-5273-1.

Tornatzky, L. G., Klein, K. J. (1982). *Innovation characteristics and innovation adoption-implementation: a meta-analysis of findings.* IEEE Trans Eng. Manage; 29(11):28–45.

UNICITRAL (2013). *Recognizing and Preventing Commercial Fraud*. United Nations Commission on International Trade Law. NY.

Van Dokkum, K. (2013). *Ship Knowledge. Ship Design, Construction and Operation* 8th Ed. Dokmar, Netherlands.

Vergara, J., McKesson, C., Walczak, M. (2012). *Sustainable energy for the marine sector.* Energy Policy, volume 49.

Ward, R. (2016). *A billion-dollar digital opportunity for oil companies*. Retrieved from: http://www.mckinsey.com/industries/oil-and-gas/our-insights/a-billiondollar-digital-opportunity-for-oil-companies.

World Energy Council (2016). Retrieved from http://www.worldenergy.org

World Energy Outlook (2016). Retrieved from http://www.worldenergyoutlook.org

Yli-Huumo J., Ko D., Choi S., Park S., Smolander K. (2016). *Where Is Current Research on Blockchain Technology? A Systematic Review*. PLoS ONE 11(10): e0163477. doi:10.1371/journal.pone.0163