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Emperor's New Blockchain: An Overview of the Technology Adoption within the Maritime Industry

Master of Science Thesis
in the Maritime Management Programme

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Division of Maritime Studies
CHALMERS UNIVERSITY OF TECHNOLOGY
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ABSTRACT

Prior research on blockchain implementation in the maritime industry has praised the technology beyond its technical limitations perceiving it as a universal solution to overcome a myriad of problems. This thesis explores the blockchain technology adoption concerning the theory of mindfulness by presenting five blockchain use cases. Mindfulness implies that technology is thoroughly investigated when it comes to local contexts and alternative technologies, and it is adopted as the best task-technology-fit solution. However, the key findings in this thesis reveal that the adopters of the blockchain technology have little knowledge about what they are adopting or consciously adopting only the blockchain term and not much evidence of the technology itself. The findings from this study also contradict many exaggerated benefits previously attributed to the blockchain. This thesis dispels blockchain's myth and stresses out the importance of adopting the technology deliberately for its merits and not based on its hype.

Keywords: Blockchain; Mindfulness in Technology Adoption; Maritime

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1 INTRODUCTION

This chapter firstly presents the topic area of the thesis and the importance of this research. It presents the purpose of the current research by defining the main research questions the student aim to explore. Subsequently, the delimitations of the thesis are identified, and finally, the thesis outline is presented.

1.1 Background

In 2009 we witnessed blockchain proof-of-concept within the electronic-currency industry, since then it became a mainstream quest within other sectors as well from real-estate to banks, healthcare sector, the insurance industry, government agencies, non-profit organisations and many others (Laurence, 2017). Blockchain is described as a "system based on cryptographic proof instead of trust, allowing any two willing parties to transact directly with each other without the need for a trusted third party" (Nakamoto, 2008a, p. 1). According to Gartner's *Hype Cycle for Blockchain Business*, blockchain in the supply chain, logistics and transportation is at its peak of inflated expectations (Gartner, 2018).

A few examples of blockchain deployment within the maritime industry are: A.P. Moller-Maersk and IBM formed TradeLens to provide "a blockchain-enabled shipping solution designed to promote more efficient and secure global trade, bringing together various parties to support information sharing and transparency, and spur industry-wide innovation" (A.P. Moller Maersk, 2018).

In 2017 Pacific International Lines (PIL), PSA International Pte Ltd and IBM Singapore signed a Memorandum of Understanding (MoU) and conducted a successful blockchain trail achieving the following objectives: "1) transparent and trustworthy execution of multimodal logistics capacity booking, 2) regulatory-compliant execution of multimodal logistics capacity booking process, 3) real-time track and trace, 4) permissioned access control for ecosystem participants" (PSA, 2017).

Similarly, an MoU was signed in 2018 between ocean carriers: CMA CGM, COSCO SHIPPING Lines, Evergreen Marine, OOCL, and Yang Ming, plus terminal operators: DP World,

Hutchison Ports, PSA International Pte Ltd, Shanghai International Port, and a software solutions provider: CargoSmart, to form a blockchain consortium (Cargo Smart, 2018).

In Europe, Port of Rotterdam Authority announced in 2018 a collaboration with ABN AMRO, Samsung SDS to launch a container logistic blockchain pilot (Port of Rotterdam, 2018). Similarly, Port of Antwerp announced in 2017 that "T-Mining develops Blockchain solution for safe, efficient container release" in port (Port of Antwerp, 2017).

Additionally, marine fuel assurance and crew certificate using blockchain technology sponsored by Lloyd's Register Foundation (Maritime Blockchain Labs, 2018), and Blockchain-based Smart Bill of Lading from CargoX (Kukman, 2018).

Like any decision-making process, technology adoption implies an evaluation of the problem and the technology fit, cost-benefit analyses and comparison with other IT-solutions, financial resources, and expectations of a positive return on investment (Soriano, 2012). Despite published studies, there is still a lack of knowledge about the blockchain application within the maritime industry. Due to this, for practical implications, it is necessary to explore if such blockchain use cases are based on sound analyses and mindful approach, or the industry blindly follows other adopters before engaging with the technology and adopts the blockchain for its hype and not for its distinguishing features.

Furthermore, the interest in blockchain technology has also increased within academia. A review of the literature reveals that in 2012 only one paper was published on blockchain subject, today searching the "blockchain" term on a university's database gives you more than fifty thousand results (Appendix A). However, there is still little knowledge and understanding with regards to proof-of-concept and legitimate use cases beyond the industry of digital-currency. Therefore, there is a need for exploring if the blockchain technology is adopted for its novel features or if it is one of the buzzwords within the maritime industry.

1.2 Purpose and Research Questions

The purpose of this thesis is to explore blockchain use cases within the maritime industry in terms of *Mindfulness of Technology Adoption* approach and to review the evidence and results from blockchain implementation in the maritime sector presented in the academic literature. Based on the stated purpose, the following three research questions have been formulated:

RQ 1: What lessons can be learned from previously published studies about the implementation of blockchain technology in the maritime sector?
RQ 2: What is the evidence and results from the adoption of blockchain technology in the maritime sector?
RQ 3: Why companies choose blockchain instead of other databases for their scope?

1.3 Delimitations

In pursuance of the thesis' purpose, first clear delimitation will be the blockchain technology adoption only within the maritime industry. Such delimitation is mainly made because the thesis is written as part of the "Maritime Management" program. *Maritime industry* is defined as: "all companies that own, operate, design, build, deliver equipment or specialized services to all types of ships and other floating units" and the industry is divided into four major groups: (1) shipping; (2) maritime finance and law; (3) maritime technology; (4) ports and logistics (Jakobsen, Mellbye, Osman, & Dyrstad, 2017, p. 38).

Another delimitation is related to blockchain's technical aspects; the student does not intend to present complicated algorithms related to blockchain technology that she herself does not understand, or it will be of little interest for readers. Blockchain will solely be explored for gathering adequate knowledge to understand its implications and to be able to analyse data collected.

1.4 Thesis outline

The thesis is structured as follows: C*hapter 2* encompasses the frame of references aimed to introduce the theoretical concept. It presents blockchain's basics and the differences compared with other technological solutions as the foundation of this research, which later will be used to understand and analyse the empirical findings. In *chapter 3* will be presented the methodology applied for the scope of this thesis. *Chapter 4* summarises and accounts for the findings from the literature review and the key findings from the blockchain use cases. *Chapter 5* is a discussion aimed to interpret the results of this thesis, and a contemplation on how the findings of the report align with the research of others. C*hapter 6* presents the main findings of this thesis. It will also

address what value this research might add to the previous work in the field, the level of uncertainty for the results, and it will present suggestions for further studies.

2 FRAME OF REFERENCES

This chapter lays out the frame of references which will serve as a mainstay for the research approach and to analyse the results of the thesis. It is divided into two sections. The first out is an introduction to the mindful approach of technology adoption by presenting the relevant theory. The second part covers blockchain's architecture and design; the technology's basics are thoroughly explored and compared with other databases.

2.1 Mindfulness of Technology Adoption

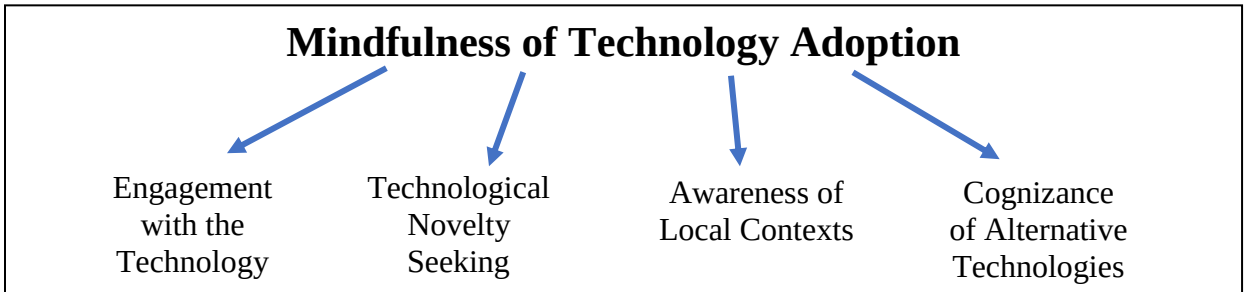
The *mindfulness* concept is a relatively new approach in Information Technology (IT) field with regards to technology choice and adoption (Sun, Fang, & Zou, 2016; Swanson & Ramiller, 2004). Mindfulness has its origins in psychology— is a cognitive state that humans possess, but lately, it has been adopted for assessing the organisation's decisions (Swanson & Ramiller, 2004). "[A]n organization is *mindful* in innovating with IT when it attends to an innovation with reasoning grounded in its own organizational facts and specifics" (Swanson & Ramiller, 2004, p. 559). Besides making rational choices and assessing the need and the opportune time for innovation, mindfulness is also a prerequisite to avoid *herd behaviour* (Darban & Amirkhiz, 2015) and adopting a technology contrary to one's own need and interest.

Conversely to mindfulness, decision-makers could also be subject to *mindless* actions. According to Swanson & Ramiller (2004), organisations are mindless in innovating with IT when the companies' requirements and business' specifics do not align with the solution adopted. The mindless-decision of adopting an unfit technology might be a result of the insufficient technology exploration, blindly following other adopters without grasping essential IT competencies or relying on consulting companies selling a solution to introduce them to the new technology (Swanson & Ramiller, 2004).

Relying on IT-companies to decided what solution fits best the business problem without a personal understanding of the technology's features and its implications could lead to *asymmetric information*. The asymmetric information is the knowledge-gap between technology adopters (principle) and IT-consulting firms (agent) selling the solution. When there is a *principle-agent problem*, there is a risk of moral hazard (Pauly, 1968; Rogerson, 1985) or adverse selection (Akerlof, 1978). Moral hazard is not a predetermined effect, but it has a high probability to occur

when the "agent" knows more about the IT-solution than the "principle" does. *Engagement with the technology* is a mindful approach meant to mitigate such problem and subsequently lead to a better symmetry of information between the parties involved.

Sun et al. (2016) proposed a Mindfulness of Technology Adoption (MTA) framework based on Langer's four dimensions of mindfulness to evaluate the extent to which a technology is consciously adopted. According to Sun et al., "MTA means that a person investigates technology in detail and in relation to local contexts and alternative technologies" (Sun et al., 2016, p. 380). Figure 1 below is a representation of these four dimensions that can support a sound and legitimate technology-adoption decision.



Dimension (Langer's (1989a) original dimensions are in parenthesis)	Definition	Example
Engagement with the technology (active information seeking and processing)	The degree to which a person actively seeks information about the technology in terms of its functionalities.	A person explores the functionality of Open Office in detail when adopting it.
Technological novelty seeking (constant creation of new category)	The degree to which a person compares the technology with existing technologies so that the individual is more aware of its uniqueness.	When adopting SPSS, a person compares it with Excel with which the individual is familiar to figure out how SPSS is different from Excel.
Awareness of local contexts (awareness of local specifics)	The degree to which a person thinks about how the technology fits the individual's local specifics and own needs.	Instead of the popular Oracle Database 12c, a person decides to use MS Access for their small business.
Cognizance of alternative technologies (openness to alternative technologies)	The degree to which a person is aware of a technology's alternative options and their advantages and drawbacks.	When considering adopting IBM Cognos as a business analytics solution, a person is also aware of other alternative solutions such as Tableau and SAS.

Figure 1: *Four Dimensions of MTA* (Sun et al., 2016, p. 381)

Engagement with technology implies thoroughly collecting information about the technology and its features and accurately comparing it with other solutions. In addition to alleviating the asymmetric information, engagement with technology will lead to a proper understanding of the technology's unique features, so the technology adopter could deliberately compare blockchain solution with other technologies and choose blockchain for its novel features, or as a result of careful cost-benefit analysis. Thus, it will be a mindless action to use blockchain technology for other than its distinguishing features without acknowledging that choosing other technologies might imply cost savings or it could better accommodate the problem.

Ignoring the mindfulness approach when innovating with IT "can reasonably be entertained whenever and wherever its likely rewards outweigh its risks" (Swanson & Ramiller, 2004, p. 566). In case it doesn't, then the organisations will record a sunk cost or "for better or worse, [the users will have to] use information technologies in ways designers never imagined" (Butler & Gray, 2006, p. 211). However, despite one's imagination, technical limitations, i.e. the design and architecture of the technology will always hinder how creative the organisation can use the technology.

2.2 Blockchain Technology

Blockchain is the name attributed to the technology that underpins the Bitcoin cryptocurrency — a form of electronic money based on cryptography— and another related cryptocurrency ecosystem (Mougayar, 2016; Narayanan, Bonneau, Felten, Miller, & Goldfeder, 2016). The blockchain technology is a decentralised distributed ledger that uses the *cryptographic hash function*, *digital signatures* and *timestamp server* and allows peer-to-peer transactions by creating immutable chains of transactions in an incremental linear record of blocks (Nakamoto, 2008a; Narayanan et al., 2016).

While there is no standard definition for blockchain, it is easy to agree on what blockchain means in its technical and theoretical implication. According to Satoshi Nakamoto, blockchain is defined as: "A solution to the double-spending problem using a peer-to-peer distributed timestamp server to generate computational proof of the chronological order of transactions" (Nakamoto, 2008a, p. 1).

Although "blockchain" was used as two simple words when Nakamoto released the Bitcoin's source code (Trottier, 2013) later, it emerged as an umbrella term for different databases within the industry and academia (Buterin, 2015; Siba, Tarun, & Prakash, 2017). At the moment the technology is seen as a support for a variety of activities beyond the cryptocurrency application (Campbell-Verduyn, 2018).

Blockchain mechanisms existed long before Satoshi Nakamoto introduced Bitcoin (Halaburda, 2018; Narayanan, 2018) – *hashcash function* (Back, 2002) *peer-to-peer network* (Barkai, 2002; Oram, 2001) *probability theory* (Feller, 1950) *non-cooperative game theory* (Nash, 1951) and *double-entry system* could be traced back to Luca Piccioli (Herlihy, 2019).

Blockchain technology is an innovation that resulted from a combination of all these mechanisms applied in a new way (Laurence, 2017) to serve a specific scope. As Mike Gault, the CEO of Guardtime said it in an interview: "…the genius behind [blockchain] it was taking different cryptographic building blocks and building a cryptocurrency protocol that incentivizes people to use it" (According to Jeffries, 2018).

The unique technology's feature is the solution for the *double-spending problem* without relying on a trusted third party to facilitate digital transactions. Furthermore, blockchain protocol is designed to make reversible transactions computationally impractical in order to protect consignees and also consigners could be protected be deploying escrow mechanisms built into its design (Nakamoto, 2008a, 2010).

Since Nakamoto published the Bitcoin white paper, the technology has been evolved (Mow, 2018) and many improvements have been proposed (Kokoris-Kogias et al., 2016; Zamani, Movahedi, & Raykova, 2018) but its central architecture and design remains the same; or as Nakamoto said: "The nature of Bitcoin is such that once version 0.1 was released, the core design was set in stone for the rest of its lifetime" (Nakamoto, 2010). In the following sections, the basics of blockchain technology will be presented, followed by a review of the main differences between blockchain and other regular databases.

2.2.1 Blockchain Architecture and Design

Main characteristics that make the blockchain's legacy is a *combination* of technologies: (1) peer-to-peer (P2P) network; (2) digital signature; (3) timestamp server; (4) cryptographic hash function;

and (5) an incentive mechanism that accounts for the benefits of this technology. Hereunder each of these pillars will be further discussed and presented in detail.

Peer-to-peer (P2P) network

Blockchain is based on a P2P network. A P2P network depicts a distributed architecture where interconnected computers – *peers* (Vlachou, Doulkeridis, Nørvåg, & Kotidis, 2012) – independently share resources, i.e. Central Processing Unit (CPU) power without relying on a central server. Peers or computers in a P2P system are also called *nodes*. Contrary to a centralised network where a central server controls and coordinates every node, in a decentralised distributed network, every node serves as clients and servers (Figure 2).

Decentralisation on Blockchain is accomplished due to a *distributed consensus.* According to Coulouris, Dollimore, & Kindberg, (2001), distributed consensus in computer science implies to achieve an agreement on some data along with several faulty processes (nodes).

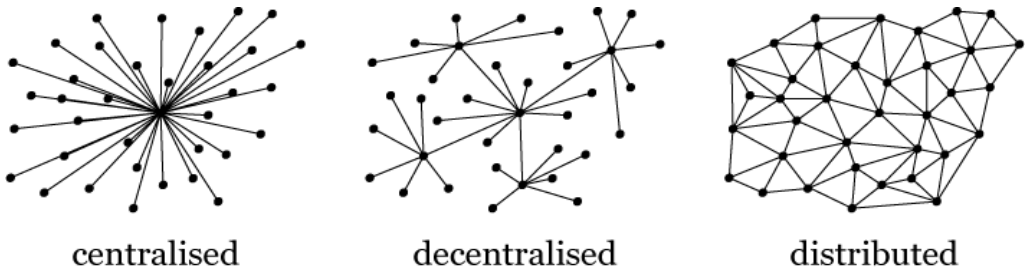


Figure 2: *Centralised-decentralised-distributed network.* Licensed under Creative Commons CC BY-SA

Narayanan et al., (2016) mention two requirements the blockchain protocol must satisfy when solving the consensus problem and attain network reliability: (1) the consensus problem is solved when all honest nodes agree on the value; and (2) an honest node must have generated the value. On the blockchain, the consensus is attained *implicitly* when a majority of nodes accepts the last block of transactions by using its hash to build the next block in the chain (more about this will be presented in the next sections). That is, decentralisation on the blockchain is achieved on the strength of all nodes participating in the transaction-validation process and coming to the same conclusion.

Digital signature

In a digital environment, transactions take place after an *authentication* and *authorisation* procedure is performed, i.e. *digital proof* as a tool to build trusted relationships. Transaction on the blockchain takes place when transaction initiator, owner of a *private key* digitally signs the *hash* of the previous transaction and the *public key* of the transaction counterparty (see Figure 3) (Nakamoto, 2008a). A timestamp server accomplishes the order of the transactions.

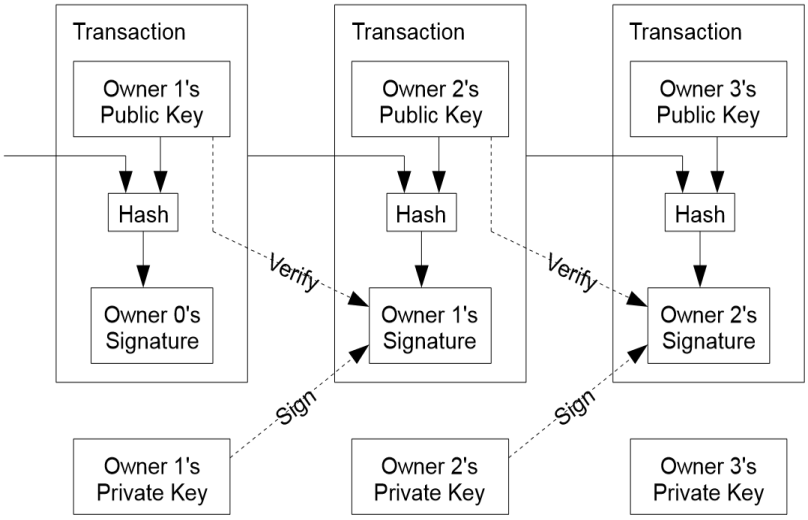


Figure 3: *Blockchain's peer-to-peer transaction* (Nakamoto, 2008a, p.2)

Timestamp server

Since blockchain is based on a P2P network without a central authority, Nakamoto first step to solving the double-spending problem is to *timestamp* the transactions and make all transactions public to the entire network (Nakamoto, 2008a). The timestamp server is part of the consensus mechanism – a solution to help each node to identify which transaction came first.

New transactions are broadcast to all nodes in the network, and every node gathers the transactions into a block performs the *proof-of-work* and then broadcast the solution (the valid block) to the network (Narayanan et al., 2016). Hence, transaction validation takes place. The transaction authorization happens when the entire network or a sufficient number of nodes perform the proof-of-work according to the blockchain's protocol (Nakamoto, 2008a) and reach consensus

by accepting the valid block into the chain and use its hash to create the next block, and so on (Narayanan et al., 2016) (Figure 4).

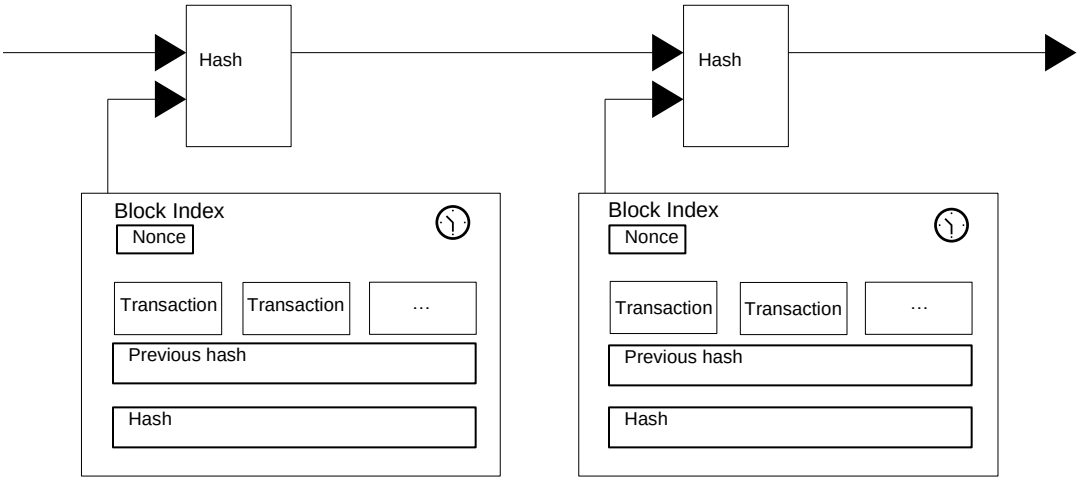


Figure 4. *Block creation*. Nakamoto (2008a) and Narayanan et al. (2016)

Each block contains the following information: *Index*- indicates the block position in the chain. The first block is called *genesis block* and will have index 0, and the next block will follow the natural number string; *Timestamp*- is the time record of block creation; *Hash*- is a digital identity of data; *Previous hash*- it is the hash of the previous block; *Nonce*- is a number that will compute a valid hash.

Cryptographic hash functions

A cryptographic hash is a mathematical algorithm that takes data of any size as input and generates a fixed-length alphanumeric value as output (Smart, 2016). On the blockchain, data is interference of index, timestamp, block transactions, the hash of the previous bock and nonce (Narayanan et al., 2016). Mathematically written this will be:

$$f(\text{data}) = \text{hash} \quad \rightarrow f(\text{index} + \text{previous hash} + \text{timestamp} + \text{transactions} + \text{nonce}) = \text{hash}$$

The proof-of-work also accomplish a distributed timestamp server on a P2P network (blockchain uses CPU power to perform the proof-of-work) (Nakamoto, 2008a). The "The proof-of-work involves scanning for a value that when hashed, such as with SHA-256, the hash begins with a number of zero bits" (Nakamoto, 2008a, p. 3). The SHA-256 hash stands for Secure Hash Algorithm and has an output of 256 bits. Additionally, to the proof-of-work application, it is also used as a security instrument to attain a security level of 128 bits necessary for a collision-resistant hash (Smart, 2016).

As Narayanan et al. said: “Hash functions are the Swiss Army knife of cryptography” (Narayanan et al., 2016, p. 10). The main proprieties that differentiate a cryptographic hash from any hash used in computer science are (Smart, 2016):

(i) *Preimage Resistant*: It is impossible to convert hash into data. This property is also known as *one-way*.
(ii) *Second Preimage Resistant*: Same data should always depict the same hash value.
(iii) *Collision Resistant*: Different data always reflects a different hash.

Since each newly added block is chained with the hash of the previous block (see Figure 4), looking backwards at data record, each block’s hash points towards the previous block. Narayanan et al. (2016) call this hash’s function: *Hash pointer* (Figure 5). This scheme permits to prove that data has not been tamper.

The same hash value inters two different blocks, similarly to the *duality principle* in the double-entry bookkeeping system (Tulsian, 2006). Hence, any data interference will affect all the following blocks, and in order to validate a tampered chain it will imply redoing the proof-of-work for the affected block and all the subsequent blocks after it (Nakamoto, 2008b). This principle (along with other principles which would be presented in the next section) requires costly CPU power, thus makes the blockchain immutable (Halaburda, 2018).

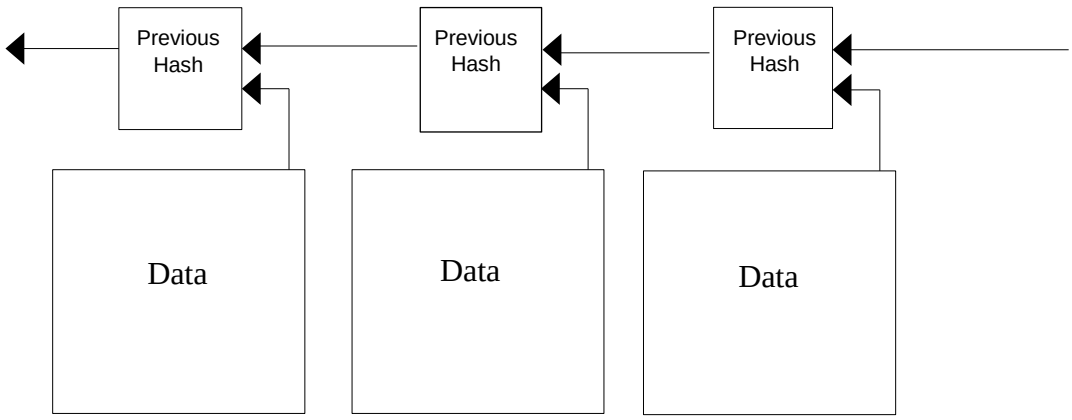


Figure 5: *Hash pointers*. Adopted and modified from (Narayanan et al., 2016, p.11)

Incentive mechanism

Blockchain's technical design also incorporates an *incentive mechanism* that it has been built into. As Narayanan et al. said: "[Blockchain] is partly a technical mechanism and partly clever incentive engineering" (Narayanan et al., 2016, p. 38).

The incentive mechanism is the main element that powers blockchain distributed consensus and ensures that its decentralised distributed ledger will function according to its protocol and retain the chain unimpaired. Furthermore, the incentive mechanism is also considered to be one of the explanations why blockchain consensus protocol works and different *impossibility results* like Byzantine Generals Problem or Fischer-Lynch-Paterson related to distributed systems (Coulouris et al., 2001) are irrelevant to blockchain technology (Narayanan et al., 2016)

An *incentive* could either be a reward for conforming to specific rules or punishment for breaking the rules in certain conditions or circumstances. Several researchers have proved that rewards and punishment both endorse cooperation in different social dilemmas (Lange, Rockenbach, & Yamagishi, 2014). Lange et al. define *social dilemma* as "situations that involve a motivational conflict between choosing to do what is best for oneself or what is best for the collective" (Lange et al., 2014, p. 34).

Blockchain's incentive mechanism implies a *reward* for each new block created. The node gets to add the reward in the form of currency (new coins are generated) as the first transaction in the next block (Narayanan et al., 2016). In other words, each peer that creates a valid block receives its reward for creating the last block in the next valid block that will be added to the chain. "Rational choice theory predicts that people will not cooperate in social dilemmas unless their own interests are aligned with others" (Hargreaves, Heap, & Varufakis, (2004) according to Lange et al., 2014, p. 34). Thus, blockchain is secure and fault tolerance because the incentive mechanism is designed to align each node's own interest with others and motivates the peers to make rational choices.

Furthermore, it is essential to mention that the reward also covers the expenditure incurred, i.e. computational time and power the nodes employ when performing the proof-of-work; and in case of transactions with a lower output value than its input, the remuneration is in the form of *transaction fee* (instead of creating new coins) (Nakamoto, 2008a, 2009; Narayanan et al., 2016).

2.2.2 Non-cooperative Game Theory

Since the blockchain network is independent of a central authority, the technology relies upon an incentive mechanism to preserve its P2P network honestly and the system fault tolerance. In order to understand this mechanism and how it motivates the nodes to behave honestly, it is necessary to refer to the game theory approach. A *game* is any interaction between multiple rational individuals in which each person's payoff is affected by the decisions made by others (Myerson & Eichberger, 1993).

Game theory is used to analyse decisions different players might make under various circumstances. On the blockchain, the decision-making is based on CPU instead of IP-address, so the system is protected from any malicious node that might allocate multiple IP addresses, therefore: "one-CPU-one vote" (Nakamoto, 2008a).

Blockchain's protocol falls under the *non-cooperative game theory* branch (Nash, 1951). Each peer competes with all other peers in the network to solve the proof-of-work and receive a reward (coins for creating a valid block). In a non-cooperative environment, players (nodes) do not trust each other, and each player's strategy is a selfish choice that will leave them better off independently of what other players may decide to do — which means they will reach a *Nash equilibrium* (Nash, 1951; Nash, 1950).

Even if a node accumulates more CPU than all the honest peers in the network, it will continue applying the selfish strategy. Hence, he will have to select between two options (strategies) in this game: (1) devote the CPU power to generate new coins and continue to add blocks to the chain or (2) deplete the same CPU power to double-spend the same transaction. "He [every node] ought to find it more profitable to play by the rules, such rules that favour him with more new coins than everyone else combined, than to undermine the system and the validity of his own wealth" (Nakamoto, 2008a, p. 4). In other words, the Nash equilibrium for each node under the blockchain protocol setting is to play by its rules, i.e. use the CPU power to validate the next block in the chain and gain new coins.

2.2.3 Differences between blockchain and other databases

Blockchain is a type of database that has similarities and differences with other traditional databases. This section will present the differences between blockchain and other databases in terms of advantages and disadvantages.

Firstly, it is necessary to address in what aspects blockchain does not differentiate from other databases. Blockchain and other regular databases have the following features in common:

1. **Smart contract**: *Smart contract* is a program code that was first described by Nick Szabo as a technical mean to solve the same disputes as any regular contracts do (Szabo, 1998). Smart contract on blockchain is a *script* (predicative) that generalises the transaction information, so the computer program could evaluate whether the conditions of the parties involved are met (Nakamoto, 2010). However, this feature is not exclusively characteristic to the blockchain, so *stored procedures* can do in relational databases (Coffin, 2011; Kuassi. Mensah, 2006).

2. **Reliability**: Blockchain is *reliable*, which means that even a node (or a few computers) fail the network will continue to operate accordingly. This characteristic could also easily be attained by *duplicating* or *replicating* a distributed database (Coulouris et al., 2001) or by having a *multi-master copy* of the central database.

3. **Atomic cross-chain swaps**: Blockchain enables *atomic cross-chain swaps*, this means that it is possible to have a "single transaction that swaps currency or assets controlled by different people or entities" (Narayanan et al., 2016, p. 257). However, such atomic transactions where "*EITHER*" all transactions succeed "*OR*" all are rolled back in full (Korotkevitch, 2015) are also possible on a regular database.

4. **Append-only database**: *Append-only database* means that the database only permits to add transaction into the blockchain and no one can delete anything from the ledger. However, exact the same procedure it is possible with a central database by customising fields to allow users only to add information (Frye, 2010).

Secondly, equally important is to examine in which circumstances blockchain underperform the regular databases. Thus, due to its P2P network, transactions on blockchain consumes more time than a centralised database do; the majority of nodes must reach consensus before a block of transactions could be recorded.

Another drawback with blockchain related to transactions is *scalability*. Blockchain network has a lower transactions throughput (limited at seven transactions per second at the moment) comparing with other systems (Narayanan et al., 2016).

Furthermore, Narayanan et al. (2016) explain different methods to deanonymize blockchain data. Despite that the data on the blockchain is anonymous, it is not confidential since there are multiple easy ways to link the data to a real-world identity. That is a significant disadvantage comparing with the level of privacy a central database would offer.

Finally, the main difference between blockchain and other databases is *decentralisation* in a fault system (network). Blockchain permits multiple actors to innovate and build on the network without any permission, intermediary systems or central control. Therefore, the main differences and the only advantage blockchain possesses comparing with other regular databases is decentralisation in a fault network that must reach consensus.

That is, in terms of latency, scalability and anonymity, regular databases are a better-off solution and will always outrun a blockchain system; smart contracts, reliability, atomic cross-chain swaps, append-only transactions are features that do not differentiate a blockchain from other systems. The unique and novel characteristic that distinguishes a blockchain from any other systems is decentralisation.

2.2.4 Blockchain Summary

The following bullet point list presents a summary of the blockchain's basics review:

- Blockchain is a decentralised distributed database (ledger) which allows peer-to-peer transactions without relying on a third-party.
- Decentralisation means that there is no single party (authority/participant/computer) to control the database; instead, all data either currency, information, assets are broadcasted to the entire network, and everyone is entitled to modify the database.
- Not only that all transactions are distributed across its network, but the decision-making process is also distributed based on CPU. Thus, each participant in the network votes and decides which transaction (block of transactions) is valid. That is happening by the instrumentality of the implicit distributed consensus.

- Blockchain implies no central authority. Hence, the solution to the double-spending problem is a combination of a P2P network, a timestamp server, cryptographic hash function, CPU proof-of-work and an incentive mechanism.
- On blockchain all transactions are digital signed, timestamped and added into a block; each block in the chain is linked with the hash of the previous block forming an immutable chain of transactions in an incremental linear record of blocks.
- Blockchain is mainly immutable because each hash value is double-entered in the system, and because the incentive mechanism aligns each node's own interest with other peers' interest and finds them in a Nash equilibrium when following the protocols' rules.

To conclude, the invention of blockchain technology was the result of a well thought out combination of different technologies and theories or as Satoshi Nakamoto said: "much more of the work was designing than coding" (Bitcoin Forum, 2010).

3 METHODOLOGY

This chapter presents the research approach and design that underpins the study. Furthermore, it will discuss how data was collected and analysed, the quality of the research in terms of validity and reliability and ethical considerations.

3.1 Explorative research approach

The thesis' research approach is an explorative case study (Yin, 2014). According to Yin (2014), having a firm grasp of issues being studied is one of the attributes any researcher should master before proceeding to explore a phenomenon.

Understanding the phenomena being studied in the first place is a prerequisite "because analytical judgements have to be made throughout the data collection phase… [and the researcher] must be able to interpret the information as it is being collected and to know immediately, for instance, if several sources of information contradict one another" (Yin, 2014, p. 76).

A heuristic literature review was performed in order to engage with blockchain technology and to understand the technology's distinguishing features and functionalities. This exercise begins with tracing the origins of blockchain technology.

The learning process started with the white paper *Bitcoin: A Peer-to-Peer Electronic Cash System* published by Satoshi Nakamoto in 2008, which introduces the blockchain technology for the first time. From that paper, concepts like hash function, peer-to-peer network, timestamp server, incentives were detailed explored.

The literature review draws on two universities' databases (lib.chalmers.se and usn.oria.no) by searching various combinations of words (Figure 6). This literature review also implied cross-reference to acquire additional data by reviewing the references from the preliminary paper.

Moreover, additional information about blockchain and how does it work was collected from a *Cryptography mailing list* where Nakamoto and other developers communicated shortly after the white paper was made available and before the Bitcoin code (blockchain technology) was released. Several articles, white papers and posts were consulted on the internet, along with online lessons by universities' professors on YouTube channels.

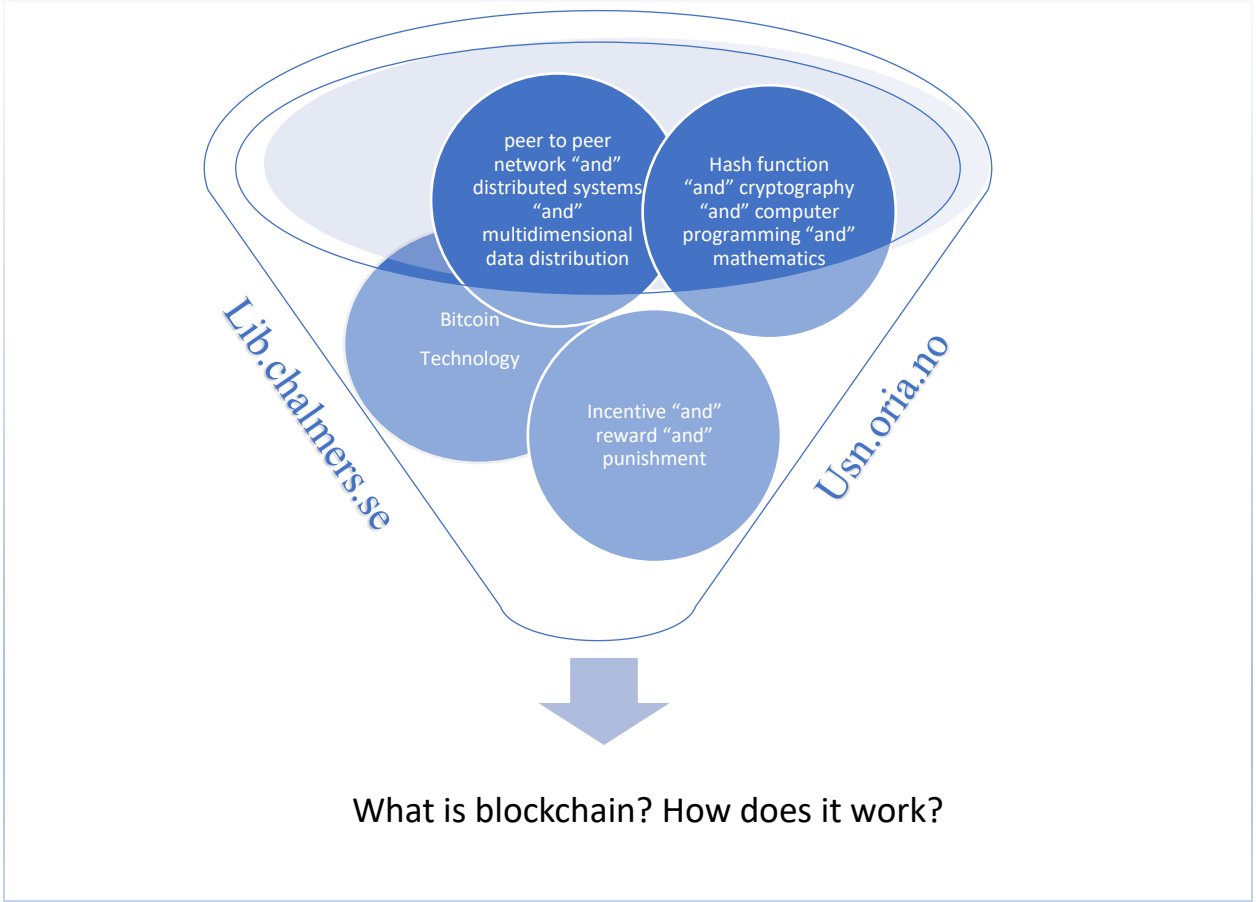


Figure 6: *Combinations of words in the literature search*

Actively collecting data about blockchain familiarised the student with the technology. The engagement with the technology had been an essential process to attain the required knowledge before starting to collect data.

3.2 Data Collection

According to Yin (2014), there are six sources of evidence to support data collection: *documentation, archival records, interviews, direct observations, participant-observation, physical artefacts*. In order to answer the research questions and fulfil the thesis' purpose, data for every blockchain use case were collected through the medium of documentation and interviews. These data gathering methods are in details presented in the next sections.

Data collection also implied a literature review to assess and compare prior research on blockchain implementation within the maritime industry. Multiple data resources were crucial to

explore the unit of analysis from different perspectives and to understand the use cases in a thorough manner (McGinn, 2010a).

3.2.1 Literature review

A *stand-alone literature review* (Okoli, 2015) was performed to identify what lessons can be learned from previously published studies about the implementation of blockchain technology in the maritime sector. The literature review implied four steps, and it is summarised in Figure 7. The first step in the literature review draws on Chalmers University library's physical and digital collection; as the resultant, 17 papers were selected based on combinations of words, subject area, and source type. Subsequently, five other papers were selected after a backward and forward search on six databases.

A paper was excluded if it was discussing any supply chain that did not mention sea shipping or any businesses from the maritime industry — the final selected papers comprised of 14 articles (Appendix B). There is a high probability that relevant articles might have been omitted from the selection process due to the combinations of words applied in the literature search and, or because of the databases used for that scope.

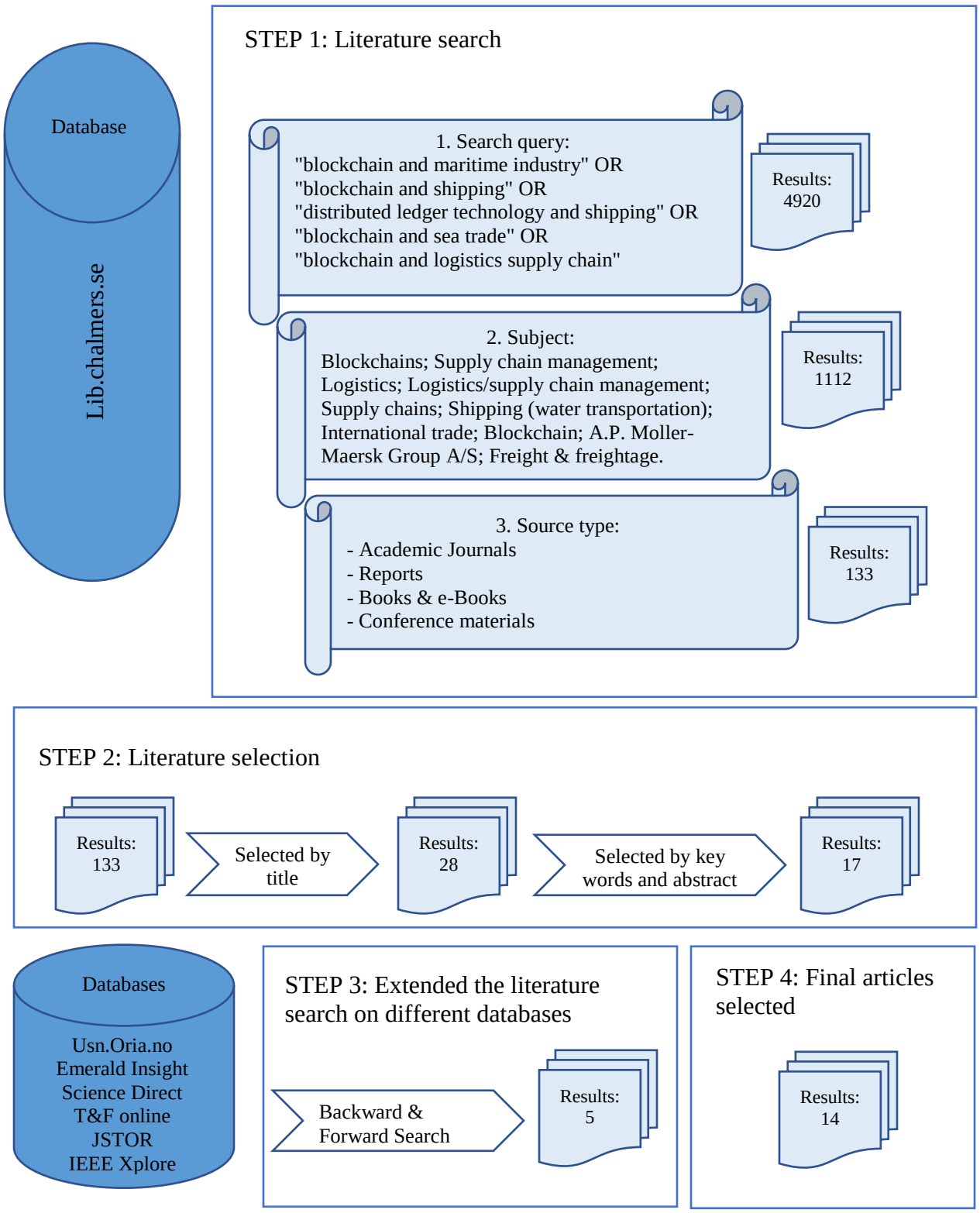


Figure 7: *Literature search and selection process*

3.2.2 Case study evidence

The unit of analysis in this case study is five individual blockchain use cases within the maritime industry. These cases were selected based on the companies' profile, i.d. their presence in the maritime sector and their experience with blockchain technology (successful adopted the technology or current running pilot projects).

Data were collected from eight companies located on the European continent and North America and implies unstructured interviews (Weiss, 1994) with nine informants (Table 1). Each interview comprises electronic correspondence (via e-mail, WhatsApp, LinkedIn) and phone or Skype calls. The interview guide (Weiss, 1994; Yin, 2014) was in line with the research questions and related to the MTA framework. Furthermore, a survey was carried out with some interviewees for clarifications (Appendix C). The questions from the survey were carefully considered and designed to evaluate, and asses to what extent the blockchain technology was mindfully adopted. Internal documents received from two companies were also reviewed for collecting evidence. In addition to this, relevant press releases from three companies were considered as a source of evidence too.

Table 1: *An overview of data collection for five blockchain use cases*

Nr. Cases	Companies' Description	Respodents' title	Data Sources				
			Skype or phone call (min)	Electronic conversations	Survey	Internal documeents	Press releases
I	Port Authority*1 plus its own solution provider	(1) CFO; (2) Product Lead; (3) Logistics and Technology Lead;	140	*		*	*
II	Blockchain provider firm for a Port Authority*2	(1) CFO	65				*
III	Digital Shipping Booking	(1) CFO and Founder	120		*	*	
IV	Blockchain provider firm plus two of their clients	(1) Project Manager; (2) Founder; (3) CFO and Founder	75	*	*		*
V	Cargo shipping company	(1) CIO		*			

Collecting evidence from multiple sources and combining different data gathering methods contributed to a broader understanding and also increased the depth of data of this thesis (McGinn, 2010b). Furthermore, multiple sources of evidence enabled the development of converging lines of inquiry (Yin, 2014).

3.3 Data Analysis

In order to move from beliefs to knowledge and reach a *truth* condition, *deductive reasoning* was applied. Deductive reasoning is a solution "to help readers make sense of the plethora of studies and to reach their own judgments about the theories of performance" (Johnson-Laird, 1999, p. 118). According to Lance J. Rips, deductive reasoning is a qualitative method to evaluate arguments from one or more premises and to infer a correct conclusion (Rips, 1990b). In this thesis *conditional reasoning* approach was applied, i.e. reasoning with *modus tollens*:

"If A then B, not B, therefore not A" (Johnson-Laird, 1999).

Along with deductive reasoning, data collected from the literature review was interpreted and structured by using g*rounded analysis* (Corbin & Strauss, 2008). At the outset, each paper was scanned separately in order to identify the key findings then according to the themes emerged all articles was designated to one or multiple categories based on their similarities or differences (Table 2). The themes emerged were formulated employing actual words used by the papers' author(s) (Corbin & Strauss, 2008).

Data from each blockchain use case studied in this thesis has been analysed by conflating multiple data sources for every single case before any findings had been generalised (Yin, 2014). For example, with some interviewees, there were extensive discussions afore and post the interview or survey participation. Therefore, all those conversations were framed to build cohesion for every case. Concomitantly each source of evidence was analysed against the frame of reference presented in this thesis.

The mindfulness of technology adoption for each blockchain use case was evaluated by considering those four dimensions of MTA mentioned earlier in the frame of reference. Thereby, moving from conceptual definition to operational definitions, a set of questions were established (Frankfort-Nachmias, Nachmias, & DeWard, 2015).

The *engagement with the blockchain technology* was evaluated by asking the respondents a collection of relevant questions related to blockchain's unique features and its benefits. The second dimension of MTA – *technological novelty seeking*, was measured against the blockchain use case presentation given by each respondent.

If the interviewee failed to provide reasonable answers, that implied a weak engagement with the technology in the first place and, namely lack of knowledge about the technology's unique features, or awareness of the context blockchain was used. Every response has also been evaluated as an indication of how well the respondent was aware of differences between blockchain and other technologies, namely *cognisance of alternative technology*. Not being able to justify the deployment of blockchain was a clear sign of mindless behaviour.

Awareness of local contexts was also assessed based on each particular use case, and all questions from the survey-part II (Appendix C) were relevant in that situation. If the interviewee does not use blockchain along with other stakeholders, then it will be inappropriate to deploy the blockchain inside a single organisation. Also, if a third party controls the database and the blockchain's participants need permission to access the system, which automatically implies that all stakeholders' identities are known, then there is no logical explanation for blockchain deployment in such case. Thus, it will be characterised as mindless with technology adoption.

The results of this thesis were analysed according to the thesis' theoretical proposition. Also, a plausible rival explanation was examined according to (Yin, 2014).

3.4 Research quality

The research quality rest upon two foundational pillars: *validity* and *reliability* (Ward & Street, 2010). Validity denotes the trustworthy of the study and refers to the correctness and accuracy of the results (Yin, 2014). Reliability refers to the stability and consistency of the report and indicates to what extent the same results and conclusion can be attained if the study were to be reproduced (Ward & Street, 2010).

The methodology applied for the scope of this thesis is thoroughly presented. Therefore, the *audit trail* should be seen as an essential tool and reproducibility of the results should be easily achievable. Furthermore, to achieve consistency, namely *equivalency* (Ward & Street, 2010) and

reduce biases in the analysis of the interviews (and literature reviewed) there is no summary of the respondents' answers. Instead, their own words are presented.

Related to conditional reasoning applied throughout this thesis, Rips advocates that an argument is deductively *valid* if "the conclusion is true in every state of affairs in which all of the premises are true" (Rips, 1990a, p. 325). Finally, *internal consistency* was achieved by data triangulation— collecting data from multiple sources (Ward & Street, 2010; Yin, 2013). Data triangulation implied: interviews, survey, and documentation for four out of five blockchain use case and a literature review.

3.5 Ethical considerations

Ethical considerations in the conduct of research represent moral principles and rules of behaviour to guide researchers throughout the research process and avoid causing any prejudice to the participants involved while seeking to achieve the research' objectives (Frankfort-Nachmias et al., 2015).

Whiting & Pritchard (2018) discuss several critical ethical issues related to research on the internet, among which what is public and what is private on the internet, and the assessment of anonymisation or attribution. Although the internet is perceived as a public space, yet there are parts, users may consider as private, and the researcher must cautiously consider what is private and what is public in the context of digital ethics (Whiting & Pritchard, 2018).

Data that already has been publicly viewed on the internet and the first source did not reject the authorship hitherto is not anonymised or given pseudonyms in this thesis. However, data that was collected on the internet through particular internet locations has been anonymised in order to protect the real identity of the participants and companies involved.

Due to a paucity of blockchain use cases available on the internet, there is a high risk that the reader could identify those cases and matching them with the information in this thesis. However, measures were taken so it will be impossible to identify the stakeholders or respondents' identity based on the results presented.

The respondents were informed that all answers would be treated anonymously, and the data collected will be analysed in the student's thesis. The survey form collected the respondents'

email addresses, and a *response receipt* was sent to each participant after they completed the survey.

The student also shared with the thesis' supervisors a redacted version of some of the data collected from interviews and electronic conversations with the stakeholders. The aim was to receive feedback on data collected without disclosing the interviewees' real identity.

4 RESULTS AND ANALYSIS

This chapter includes two parts. The first section presents several findings from the literature reviewed. The second part covers the key findings from the blockchain use cases explored in this case study.

4.1 Findings from the literature review

The literature review of prior research related to blockchain implementation within the maritime industry revealed several common themes (Table 2). Although, few articles promised examples and evidence from blockchain implementation within the maritime industry, the results are problematic, and the overall findings rely upon misunderstood theoretical concepts.

Table 2: *Themes emerged from the literature review*

Common findings	Publications
Different types of blockchain: private (permissioned) and public blockchain	(Benton, Radziwill, Purritano, & Gerhart, 2018; Gausdal, Czachorowski, & Solesvik, 2018; Kshetri, 2018; Litke, Anagnostopoulos, & Varvarigou, 2019; Macedo, 2018; Shirani, 2018; Treiblmaier, 2018; Vatsalya, Jain, Sawant-Patil, Arora, & Patil, 2018; Verhoeven, Sinn, & Herden, 2018; Wang, Han, & Beynon-Davies, 2018)
Traceability; End-to-end visibility;	(Benton et al., 2018; Dobrovnik, Herold, Fürst, & Kummer, 2018; Francisco & Swanson, 2018; Kshetri, 2018; Litke et al., 2019; Min, 2019; Tijan, Aksentijević, Ivanić, & Jardas, 2019; Verhoeven et al., 2018; Wang et al., 2018)
RFID or NFC tags enabled by IoT; Electronic data interchange (EDI), extensible markup language (XML) and application programming interface (API)	(Francisco & Swanson, 2018; Gausdal et al., 2018; Min, 2019; Tijan et al., 2019)
Misleading information about blockchain	(Gausdal et al., 2018, p. 11; Min, 2019, pp. 36–39; Tijan et al., 2019, p. 2)

Hyperledger is a blockchain; *Filecoin* is based on blockchain;	(Benton et al., 2018; Gausdal et al., 2018; Kshetri, 2018; Macedo, 2018; Min, 2019; Shirani, 2018; Tijan et al., 2019; Vatsalya et al., 2018)
Blockchain for: product origins and the freight route; measure product quality; identify the location; geolocation; eliminating counterfeiting products, theft, abuse, corruption; reducing paperwork; preventing attacks on ships;	(Benton et al., 2018; Dobrovnik et al., 2018; Francisco & Swanson, 2018; Gausdal et al., 2018; Kshetri, 2018; Litke et al., 2019; Macedo, 2018; Min, 2019; Shirani, 2018; Tijan et al., 2019; Verhoeven et al., 2018; Wang et al., 2018)
Smart contracts	(Min, 2019; Tijan et al., 2019; Vatsalya et al., 2018; Wang et al., 2018)
Mention the blockchain weaknesses	(Tijan et al., 2019)
Misconception about the blockchain's weaknesses	(Kshetri, 2018; Min, 2019)

One case study based on MTA approach that had considered use cases from secondary data suggested that several blockchain cases they have identified do not rely on blockchain's specific features and that it would rather make use of other traditional technologies instead. However, those use cases that were identified by the authors as genuine cases (according to the case's problem and the features of the technology) are based on false premises. The authors fail short to truthful identify the novel features of blockchain technology. Instead, the authors inferred that *immutability* and *traceability* are the novel characteristics of blockchain technology that are essentially needed in the case and legitimise its use.

However, the blockchain's unique feature is a solution to the double-spending problem without any third-party involvement. That is, blockchain must be seen a legitimate solution only if the ultimate purpose is decentralisation in a fault network, and not for traceability or immutability facets that could much easily and cheaply be achieved with other regular databases.

According to the literature reviewed, several papers presented blockchain specifically suited for traceability applications and end-to-end visibility along global supply chains (Table 2). However, such claims must be cautiously treated. Blockchain is not the best solution for traceability scope. Despite this "transparency" with pseudonymity, there is not much use of such traceability and end-to-end visibility when blockchain participants' identity is anonymous.

None of the articles reviewed had discussed what value such visibility and traceability brings to the network-users when the only visible data is a random of alphanumeric identities. Moreover, if, whenever and wherever someone would like to deploy a blockchain with real identities, such a solution might not be the best fit due to the individual's business context and industry's specifics.

Furthermore, previously published literature suggests that blockchain can be used together with tracking technologies such as RFID or NFC tags enabled by the Internet of Things (IoT), or electronic data interchange (EDI), extensible markup language (XML) and application programming interface (API). Subsequently, this will enhance the asset traceability, provide auditable data, permit the exchange of immutable data among multiple actors and create a sustainable supply chain.

However, such a creative combination of technologies with blockchain is not supported by any arguments or discussions to explain how, and what is the role of blockchain in this equation. Moreover, there is a disconnection between the benefits attributed to blockchain coupled with those technologies mentioned above.

Numerous articles advocate the existence of several types of blockchains (Table 2). Ten out of 14 publications reviewed have mentioned that there are different types of blockchain, like a *public* or *private (permissioned) blockchain*. According to their technical description, private or permissioned "blockchain" is nothing more than a central database or a distributed system depending on how many processors the storage devices are connected to. These authors exhibit a meagre engagement with blockchain technology.

Furthermore, misleading information about blockchain technology does not stop here. Some authors took credit for the invention of blockchain without accrediting Satoshi Nakamoto as its developer. Others insinuated that blockchain idea dates back in 1991 and only in 2008 it gained significance. Some authors believe that blockchain is bitcoin and provide no definition for blockchain. Moreover, others suggested that blockchain, namely "private blockchain" do not exist as of today. Although, their "private blockchain" described solution and proposed framework look very similar to a central database we had around for years.

The literature reviewed also reveals that several authors unflinching labelled the *Hyperledger* as a "blockchain", while others were slightly discreet, mentioning IBM and Maersk solution as a blockchain example. However, there are overwhelmed evidence that Hyperledger is

not a blockchain. The most conspicuous proof is the "permissioned" or "private" epithet, which describes a central (designated) party in charge of the database that controls the access, establishes the governance model and manipulates the data.

Another non-blockchain solution – Filecoin – for marine hull insurance is also described in one of the articles reviewed. Those authors claimed that Filecoin is based on blockchain and InterPlanetary File System (IPFS), conflating the two. Actually, what they have described is an online distributed database, i.e. (IPFS). Albeit, blockchain is a type of distributed database, not all distributed systems can be termed as blockchain, and (IPFS) is definitely not a blockchain.

The majority of articles reviewed presents weak arguments, which reveal how little engagement with blockchain technology the researchers had. This conclusion is inferred based on a plethora of ridiculous claims and exaggerated attributes about blockchain. Like providing customers with information about the products' origins and the freight route; or providing an accurate way to measure product quality during transportation; or identifying the location and movement of goods; geo-location; eliminating counterfeiting, theft of goods, abuse and corruption; or reducing paperwork and increase efficiency, speed and performance.

Blockchain reducing paperwork is an obvious outcome, and like any other digital systems taking over the traditional paperwork-process will pose such benefits. Furthermore, some authors believe that blockchain can be used to prevent terrorist attacks on ships and maritime containers. Such a blockchain application seems to be an ill-founded use case and beyond the initial technology's intended purpose.

Blockchain *enabling trust* is one of the prevailing drivers to blockchain deployment in the maritime industry. It is seen as trust between participants, or trust in the information provided by trade partners, or reliability of data controlled by a central authority – and in one article it was concluded that in practice the majority deploys permissioned blockchain.

As already mentioned, "permissioned blockchain" implies a third party or a consortium of organisations acting like a third party that establishes the protocol's rules, identifies and verifies the network participants and controls who can do what in the system based on signed contracts. Of course, everyone will have access to trusted and reliable data when the network is made up of dependable stakeholder and orchestrated by legal contracts. That is how trust is created in such situations and not because of the blockchain deployment as it has been advocated.

Another “unique” feature attributed to blockchain are smart contracts. In the literature, a smart contract is considered to be immutable; it eliminates the middlemen, the effort and time to monitor and update the contract. Regarding the immutability facets, this is not an inherent attribute. The immutability comes down to what makes a network or database secure and what risks exist for that particular system being jeopardised; it does not imply that a contract is smart and cannot be tampered.

Furthermore, besides the fact that “smart contracts” are not the novelty of blockchain technology and other databases could easily achieve the same scope, it is difficult to imagine how an actual real contract with all its nuances embodied could be triggered by automatically executable code and eliminate human involvement. For example, some authors suggest that blockchain with its smart contract feature can take over the *marine hull insurance contract* and restructure the actual insurance process which implies different steps and formalities (like the Survey Report) that must be followed in order to claim the marine insurance.

Very few articles mention blockchain weaknesses and threats like scalability, performance issues, and user’s privacy. These are real drawbacks. Despite continuous improvements, blockchain will always be less scalable comparing with a centralised system because of its consensus mechanism. Blockchain’s consensus mechanism is also energy intensive and costly to maintain. Also, despite using anonymous identities, blockchain does not protect the user’s confidentiality; in such case, other databases should be considered as a better solution. Furthermore, using pseudonymous-identities without being able to connect them to real-world individuals do not work in today’s supply chain and logistics.

Nevertheless, a few authors claim contradictory results. In two of the articles reviewed, the authors stated that by using blockchain transactions speed can be increased and others argue that blockchain protects user’s privacy due to its anonymous identities.

In one of the articles, it was advocated that blockchain is a solution to cybersecurity by eliminating the risk of a single point of failure. Undoubtedly, blockchain is reliable due to its P2P network and the incentive mechanism, which eliminates the risk of a single point of failure. However, the same result could be attained with a distributed database or a central system by having a *multi-master copy* (dual or triple modular redundancy).

One of the possible explanations for the inconsistency and conflicting claims present in the literature reviewed may be due to critical misconceptions about blockchain. Very few articles

discuss the blockchain's architecture and design, and those who do have only focused on general definitions by presenting sheer derivatives.

4.2 Key findings from the case study

Reviewing multiple blockchain use cases and interviewing technology's adopters as well as blockchain service providers within the maritime industry, several key findings were found. It ought to be mention that all those blockchain use cases studied divides into two categories: (1) those who decided to build the technology in-house (by establishing a new company); and (2) those who outsourced the task.

One of the critical key findings is that all participants interviewed were deploying "private blockchain" (solutions like *Hyperledger Fabric*, *Corda,* or *Ethereum Enterprise*) or a half centralised half decentralised solution (hereafter referred to as hybrid blockchain). However, reasoning with *modus tollens*, private blockchains are not blockchain technology. That is strong evidence that the technology adopters (Table 1) have a short engagement with technology adopted, and there is a lack of understanding of the blockchain's basics.

In practice "private blockchain" is a central database or a distributed system labelled as "blockchain" by the industry; or as one of the interviewees said: "it is a fancy name for centralised database". When asking the interviewees why their blockchain technology looks like a central system, one of the respondents' justifications for adopting private "blockchain" was that "you need to [be able to] roll it out in real life as well".

The interviewees showed a lack of awareness of local contexts. The adoption of a technology that does not fit their problem or meets the business' needs is also a sign of no cognisance of alternative technologies.

It ought also to be mentioned that multiple misunderstanding concepts and conflicting definitions revealed a weak engagement with the technology adopted. Concepts like *decentralisation, centralisation, smart contracts* were defined differently by each respondent based on their business case and not based on the concept's precise meaning and basic terminology.

For example, three interviewees defined smart contracts as the digitalisation of any paper-based contract or even a regular document like a *certificate of origins*. A paper-based document

presented in a digital format does not qualify as a smart contract if it is no code involved to generalise the problem and trigger the transaction.

Blockchain implementation within the maritime industry is not what many might think of or expect, as one of the informants explained it:

> *Basically what you see today [blockchain] is a lot about documents a lot about paper documents and this is actually one of the use cases we've been doing last year, which is of course interesting, but it does not really add much value, in sense that if you are just saving the stamp of your document then blockchain is quite expensive investment to make… [and] you just keep on working like you have been doing for hundreds of hundreds of years.*

That is the matter for four cases explored in this study, i.e. adopting blockchain for sending digital documents. The respondents interviewed claimed to use blockchain to transfer documents like certificates of origin, bill of lading, phytosanitary certificates, or any other important documents. One respondent called this process: "digital 'courier' of original documents … which save time and money".

No doubt that sending digital documents via the internet would save time and money compared with the pigeon post but adopting blockchain for such a scope is a sign of an absence of the MTA. There is a simple solution for securing electronic documents: Digital signature. Such blockchain use cases are not legitime cases and score negative on all four dismissions of MTA.

In one of the cases, the blockchain-provider firm claimed that "hybrid blockchain" is a solution for secure transfer of documents, namely "proof of ownership" and, or a "single source of truth". Hybrid blockchain means that there is a trusted intermediary who receives the paper document in exchange of a "hash" called *token* (an alphanumeric identity) the blockchain's user gets to transact (transfer) among a network of known, identified, verified and trusted stakeholders. Later, when the user needs the document's information to interact and take actions in real life business, they return the token to the trusted intermediary in the exchange of the original documents. In other words, on the blockchain is only the "stamp" of the document that has no usefulness because data is kept off the blockchain system.

Likewise, "hybrid blockchain" adopters exhibit signs of *herd behaviour* and a lack of MTA. Furthermore, most respondents believed that their private or hybrid blockchain is the unique solution for transferring digital documents.

However, secure transfer of electronic documents digitally signed have been possible for decades. Also, a reliable data source could be easily achieved by other systems too. For example, an alternative solution is a distributed ledger among the network's participants. Adopting blockchain for digital signature facet or data transparency exhibits a meagre engagement with the technology and lack of cognisance of alternative solutions in that context.

Furthermore, in some cases, the respondents had no explanation for why they have chosen blockchain technology instead of other databases. Others acknowledged that they had not considered other solutions before choosing blockchain. One CFO at the end of the interview have admitted that they do not use blockchain, although they advertise that their business is "driven by blockchain".

If the interviewees in the first two cases fall in the category: mindless of blockchain adoption and adherents of the herd behaviour, those who only use blockchain as a corrupted marketing strategy should fall into a different category.

The table below is a SWOT analysis used to emphasise how the blockchain' s unique features justify some of the trade-offs a blockchain's adopter should have been considered before running any pilots. Although blockchain's weaknesses, opportunities, and threats are easily recognised, that is not the case with regards to strengths. Thus, the strength of such decentralisation and distributed consensus will have to be assessed on an individual basis and industry context.

Table 3: *A SWOT Analysis of Blockchain Technology*

Blockchain	Strength	Weakness	Opportunity	Threat
DECENTRALIZATION	?	Due to its P2P network, the consensus mechanism makes data recording slower comparing with other databases. Moreover, a distributed decentralised database requires significant storage capacity and imply substantial computational power and energy consumption.	Blockchain allows settlements between different conflicting parties to be made easily and inexpensively.	There is no use case proof outside the cryptocurrency that has been demonstrated any benefits of deploying the blockchain technology.

Based on the data from every blockchain use cases explored in this thesis, the benefits seen as the blockchain's strengths by the technology adopters are: "trust", "optimization", "instant data

access", "save time and currier money", "automation of the paper-flow process …you can see when the documents were created, at what time", "seamless coordination". Moreover, "blockchain offers transparency and a single source of truth".

If all those enumerated benefits emphasise the lack of MTA, in terms of *transparency* and a *single source of truth,* the industry is exaggerating. Firstly, pseudonymous identities do not work in logistics and supply chain. Secondly, a blockchain solution with real-world identities will never work in business life (not in the one we know today); no companies would want "transparency" and use the same database together with their competitors and those who might embrace such an idea would be subject to competition law. Thirdly, there is no logical explanation for implementing a *Byzantine fault tolerance database* inside a single company or a consortium of firms when all stakeholders are in advance verified, authorised, and contractual bounded. In other words, technology adopters have little grasping of what they are adopting.

5 DISCUSSION

Previously published studies (Appendix B) that have explored or documented the blockchain deployment within the maritime industry or investigated the benefits and opportunities for blockchain implementation are inexplicable optimistic. The entire literature reviewed is dominated by large claims of blockchain's unique performances derived from other studies; very similar to the *telephone game.* The literature reviewed presents the blockchain as a panacea for the maritime industry based on inadequate technology assessment and the task-technology-fit in those contexts.

The authors (Appendix B) seem to have researched the blockchain without any thorough understanding of the technology in the first place. This inconsistency and contradictory results would be explained by misconceptions and misinterpretation of blockchain technology. Another possible explanation for such results could be due to the conflict of interest the authors have not disclosed in their paper. Several articles referred to private providers like IBM or Linux Foundation that offer Hyperledger as "blockchain solution"; and others make use of free software license to introduce IPFS as a blockchain solution for their case.

The novelty with blockchain and its distinguishing feature is a solution to the double-spending problem without reeling on intermediaries; in result, any two parties willing to transact can make use of a *decentralised network of computers* rested upon *distributed consensus* to guard their transaction. The key findings from the cases explored in this thesis suggest that companies have adopted or plan to implement blockchain technology for other reasons than its unique features.

Blockchain use cases for sending digital documents via the internet does not imply any double-spending problem. Furthermore, electronic documents can be digitally signed and subsequently emailed.

There is overwhelmed evidence that the use cases explored in this thesis have embraced the blockchain technology in the absence of MTA. However, this result should be carefully interpreted when referring to the technology providers; despite their claims, they certainly should know that they have adopted a non-blockchain solution once they call it "private blockchain".

None of the informants acknowledged this, but their answers, data from internal documents and some companies' press release speaks for itself. In cases where technology providers are part of the company, the moral hazard comes from their own employees.

For example, it is effortless to infer that interviewees which call their blockchain solution: Hyperledger or Corda or a Distributed database, are adopting a no-blockchain. Such reasoning is possible by confronting blockchain's technical attributes with those so-called "blockchain" solutions. For more about Hyperledger Fabric see (Androulaki et al., 2018).

Furthermore, there is no reliable evidence that any respondents interviewed are indeed implementing the blockchain or if it is a simple marketing trickery. According to Reuters (2017), multiple companies that use "crypto" or "blockchain" in their names have seen their shares sky-rocket. Such an illustrative example will be one of the companies interviewed that admitted not to use blockchain, albeit they advertise that their business is driven by blockchain.

Based on the data collected throughout this case study, several stakeholders within the maritime industry are up to some changes and digitalisation here and there. However, this process seems to take place without blockchain involvement.

The key findings presented in this thesis are contradicting the results of previously published articles. Conversely to others' work in the field, this research presents a critical overview of the blockchain adoption within the maritime industry.

Despite the reduced number of companies studied, the results presented in this thesis could be extrapolated to other businesses as well, mainly because any legal business will encounter more or less the same limitations as the cases presented in this thesis. Furthermore, in this case, it is about technology with a specific design and architecture (not an abstract thing). Even if blockchain is subject to continuous improvements, the tailor-made solution will always be the same.

6 CONCLUSION

The purpose of this thesis was to explore blockchain use cases in terms of *Mindfulness of Technology Adoption* approach and to review the results presented in the academia related to blockchain implementation in the maritime sector. Much of the findings related to the use cases that have been explored reminds of the weavers' work in H. C. Andersen' fairytale "Emperor's new clothes".

RQ 1: What lessons can be learned from previously published studies about the implementation of blockchain technology in the maritime sector?

Several common themes emerged from the literature review with regards to blockchain implementation in logistics and supply chain. However, the results of previously published studies are based on false premises and present weak arguments. Furthermore, many of the articles reviewed are simple derivatives from previous studies when describing the blockchain technology.

RQ 2: What is the evidence and results from the adoption of blockchain technology in the maritime sector?

From data collected, there is strong evidence that companies claiming to use or currently running blockchain pilots do not practice what they preach. Regarding the MTA theory, there is striking evidence of lack of blockchain knowledge at the managerial level. Furthermore, there is no piece of evidence that any company interviewed use blockchain as an end-value solution. In some cases, these results are explained by no-blockchain deployment in the first place.

RQ 3: Why companies choose blockchain instead of other databases for their scope?

Some of the respondents interviewed have not considered other solutions before choosing blockchain. Others claimed several benefits that blockchain pose in their case which are related to digitalisation and paperwork optimisation.

6.1 Practical implications

It should be emphasized that no available papers have been found that thoroughly discuss the blockchain' technical aspects and its limitations in the maritime industry context. The key findings in this thesis present blockchain in a different light than it has been previously exposed within academia. The current thesis explores blockchain' technical features against different blockchain

use cases within the maritime industry; and it seems that companies are adopters of *herd behaviour*, at least when it comes to labelling their solution "blockchain".

If it is not for the sake of deceive-marketing strategy, engaging with the technology beforehand would imply a conscious technology adoption that subsequently will save resources, avoid a sunk cost and end up with the best solution for the specific task. Blockchain is an overhyped technology, thus, thoroughly exploring the technology before running any pilots might also save you from inflating the blockchain bubble.

6.2 Limitations

Main limitations related to this study is due to a reduced number of use cases explored. This limitation was mainly because of the thesis short time writing process. However, the key findings presented in this study could be generalised for other blockchain adopters within the maritime industry that share similarities with the cases discussed in this thesis. Blockchain will be the same technology indifferently of who is going to use it. Thus, future research will measure the same technology and should reflect the same results.

The methodology of this study was detailed presented, and the audit trail should strengthen the reliability of this thesis. This case study is the first work of such complexity and a new topic for the author, which explains the choice of the explorative approach.

6.3 Suggestions for further research

This thesis dismissed numerous blockchain' benefits attributed by several academics in the field. Therefore, any further research following the path which has been set in this thesis will strength these results and produce unbiased outcomes. Likewise, it is possible to further research "why" blockchain is not a good task-technology-fit for the maritime industry. Future case studies related to blockchain adoption will provide substantial evidence by using *physical artefacts* (Yin, 2014) as data sources.

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APPENDICES

Appendix A

The number of "blockchain" term search results for each year on two universities library' physical and digital collection

Year	Usn.Oria.no	Lib.Chalmers.se
2012	1	1
2013	11	50
2014	50	282
2015	342	1507
2016	916	4243
2017	2408	10528
2018	6578	29837
By 08/03/2019	783	4116

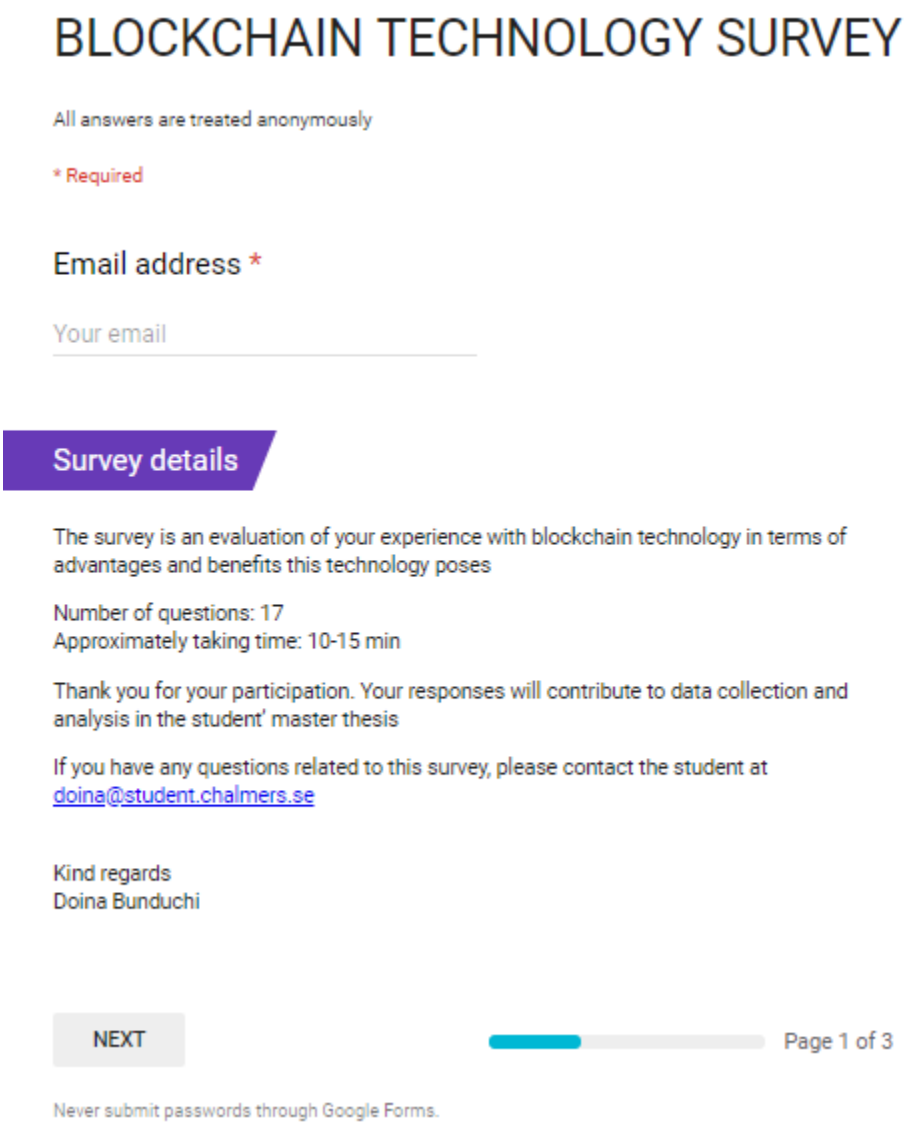
Appendix B

Final articles selected from the literature review

Journal	Publication
Supply Chain Application	Benton et al. (2018)
Sustainability	Dobrovnik et al. (2018)
Logistics	Francisco & Swanson (2018)
Sustainability	Gausdal et al. (2018)
International Journal of Information Management	Kshetri (2018)
Logistics	Litke et al. (2019)
World Customs Journal	Macedo (2018)
Business Horizons	Min (2019)
Issues in Information Systems	Shirani (2018)
Sustainability	Tijan et al. (2019)
Supply Chain Management: An International Journal	Treiblmaier (2018)
International Journal of Advanced Research in Computer Science	Vatsalya et al. (2018)
Logistics	Verhoeven et al. (2018)
Supply Chain Management: An International Journal	Wang et al. (2018)

Appendix C

Survey Template



BLOCKCHAIN TECHNOLOGY SURVEY

All answers are treated anonymously

* Required

Email address *

Your email

Survey details

The survey is an evaluation of your experience with blockchain technology in terms of advantages and benefits this technology poses

Number of questions: 17
Approximately taking time: 10-15 min

Thank you for your participation. Your responses will contribute to data collection and analysis in the student' master thesis

If you have any questions related to this survey, please contact the student at doina@student.chalmers.se

Kind regards
Doina Bunduchi

NEXT

Page 1 of 3

Never submit passwords through Google Forms.

Section 2 of 3

Part I

Your blockchain experince

1. For what exact purpose do you use blockchain?

Short answer text

2. When did you start to use blockchain? Or when are you planning to use it?

Short answer text

3. What is (are) blockchain's unique feature(s)?

Long answer text

4. Have you chosen blockchain for the feature(s) enumerated in the previous question?

- Yes
- No

5. Had you considered other technologies for this scope before choosing blockchain?

- Yes
- No

6. If the previous answer is "Yes". What other technologies have you considered?

Long answer text

7. What benefits blockchain offers in your use case?

Long answer text

Section 3 of 3

Part II

How do you use or plan to use blockchain?

1. Do you use blockchain along with other stakeholders?

- Yes
- No

2. Do stakeholders need permission to access the blockchain?

- Yes
- No

3. Are you in charge of the database/ledger?

- Yes
- No

4. Is a designated party in charge of the database/ledger?

- Yes
- No

5. Does more than one participant need to be able to update the database/ledger?

- Yes
- No

6. Are all participants known?

- Yes
- No

7. Do you trust other participants to modify the database entries?

- ○ Yes
- ○ No

8. Given your case is disintermediation more important than confidentiality?

- ○ Yes
- ○ No

9. Given your case is disintermediation more important than transactions speed?

- ○ Yes
- ○ No

10. Is your blockchain designed to use anonymous or real identity?

- ○ Anonymous
- ○ Real identity