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AN EXPLORATION OF BLOCKCHAIN ADOPTION:
Application to International Maritime Supply Chains and Cross-border Trade

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Abstract:

Blockchain has made numerous breakthroughs in the past decade as an emerging technology. The benefits, obstacles, and adoption of this technology still lack in-depth research. A qualitative research method was chosen to conduct three semi-structured expert interviews to explore adoption within the maritime supply chains in order to find how to improve the cross-border trading system. The outcomes of the thesis suggest that there is significant potential; however, the pace of adoption and the blockchain qualities employed differ. The main takeaways are that large and complex ecosystems favor blockchain adoption, but more understanding of the technology and transparent legal frameworks are required across the supply chain.

Acknowledgments:

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Keywords: Blockchain technology, technology adoption, TAM, TOE framework, maritime supply chain, ecosystem, TradeLens

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1 Introduction

"Blockchain has potential to change society", "How blockchains could change the world" and "Blockchain technology has the potential to transform government" are only a few anecdotal examples of business actors describing the transformative potential of the technology. The narrative is often that blockchain technology (BC) has the potential to be implemented within a wide array of industries and business functions with far-reaching impacts on internal processes, business models, and overall market dynamics. BT is widely considered a foundational technology that reigns in a new era of the internet, in the form of *Web3* or *Token Economy* based on principles of decentralization and tokenization. Despite the prevailing opinion of the scientific and business community about the extensive potential impact of blockchain technology, there are still comparatively few examples of implementation to date, and it has been argued that it has yet to reach its full potential.

While blockchain became widely known for its most popular use-case: Bitcoin, it is increasingly of interest to enterprises across all sectors. The adoption of blockchain technology has been a rapidly growing trend in many industries, with the wellbeing sector, the supply chain function, and the public sector being no exception. In this paper, the potential of blockchain technology to revolutionize these three sectors will be explored by applying the TOE framework, which allows the researchers to explore the most relevant aspects of technology adoption. The current state of blockchain adoption in these three sectors will be explored, and the opportunities and challenges associated with its further adoption will be analyzed. Additionally, the current literature on the topic will be reviewed, and an outlook, as well as recommendations for future research, will be suggested.

2 Theoretical Framework

2.1 A brief history of blockchain

It was back in 2008, when an unknown person or persons under the name of Satoshi Nakamoto published a paper, “Bitcoin: A Peer-to-Peer Electronic Cash System”, resulting in Bitcoin to be hailed as the first product of modern blockchain technology (Popovski et al. 2018). Essentially, the paper proposes a model in which online payment could be done without the need of a centralized authority while removing the double spending problem, i.e., duplication of digital currency, which up until that point had not been achieved (Popovski et al., 2018).

This was not the first time blockchain had been introduced, however. The original concept of timestamping was first introduced in 1991 by Stuart Haber and Scott Stornetta where they proposed a “cryptographically secured blockchain where nobody could alter timestamps of records” (Bhalla, 2021). From then on, research in blockchain took off. Bayer, Haber, and Stornetta continued pursuing their discoveries, and in 1992, they implemented the use of Merkle trees to improve efficiency (Bayer et al., 1992). Then in 1999, a paper written by Jakobsson and Juels contextualizes the term “Proof of Work” (Jakobsson & Juels, 1999). Of course, there are many other missing pieces, but essentially, blockchain’s modern technology is a combination of tools and concepts through research in the past 30-40 years.

In 2007, the financial crisis hit the global market, one that was driven by the centralized authority investing money in risky assets and fraudulent mortgages. The timing could not have been any better – moving away from the centralized authority and giving people full control of their money.

As a result, Nakamoto proposed a model whereby using ‘blocks’ that were hashed, on a distributed public ledger, the double spending problem could be resolved (Zou et al., 2020).

Additionally, to maintain consistency and structural support, the use of Proof-of-Work mechanism is applied, thereby incentivizing miners to ‘mine’ and be rewarded for their work (Zou et al., 2020). This technology is all under the peer-to-peer network, allowing transactions to be sent from one person to another. As a result of his findings, this gave way to many innovations: smart contracts, cryptocurrencies, Ethereum, etc. The following sections will provide a more in-depth analysis of the technologies involved within the blockchain.

2.2 Blockchain fundamentals

In this chapter, the basic concept of blockchain, its main features, and its properties will be introduced. This will be complemented with an outline of the most relevant use cases of blockchain technologies as well as discuss scope and limitations.

2.2.1 Traditional (central) databases vs distributed ledger systems

Businesses, governments, and other entities have access to an ever-growing amount of data (McKinsey, 2016). This data is often stored in relational databases with tables and defining dependencies (Sunyaev, 2020). However, these traditional databases are usually stored in a central place within an organization and controlled by a single authority. Examples of these include bank records stored on the banks' server, a land register of the respective PS authority assigning the property rights, and a company’s HR system storing all relevant employee data.

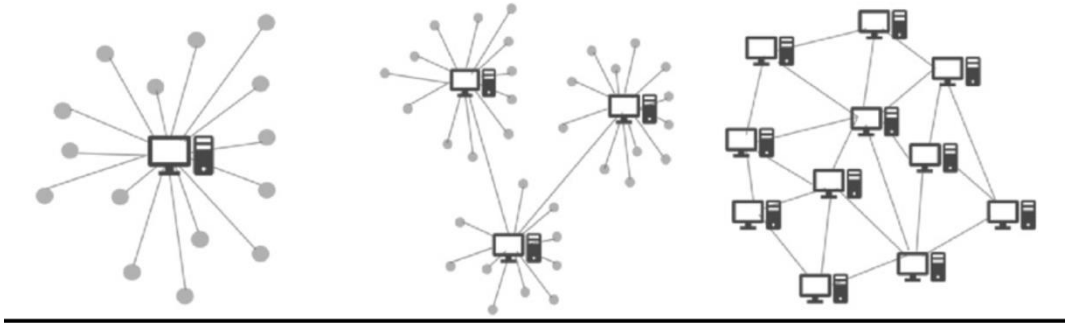
The central storage in a database has many advantages, including easy data portability as it is kept in a single location, data integrity, no redundancy, data efficiency as less storage is used, cost-effective for small organizations and effortless debugging and deployment (Gupta et al., 2022). However, the central storage of data also comes with disadvantages mainly rooted in the fact that there is a “single point of failure” when the server breaks down, data is corrupted, or someone tries to hack the database. However, another major disadvantage is the fact that they are organized by one single authority that decides on the “truth” in the database without

an auditable trail that provides transparency to other entities. As such, it requires the trust of all participating parties in the central entity that controls the content of the database.

2.2.2 Distributed and decentralized networks

Distributed ledger technologies (DLT) represent an alternative form of database in comparison to traditional central databases. As the name suggests these databases are distributed in many locations and controlled decentrally – so in the following we will take a look at the two central points of difference between these two types of databases, namely location and power. A main feature of DLTs is how the power to is decentrally distributed amongst the participants within the network. Compared to traditional centralized, there is no central entity that controls the database and its content (Theis et al., 2021). The other main difference is the location of the database. Instead of one central point with all data stored in one location, distributed networks rely on all nodes within the network to retain a local copy of the database. These points of parity can be illustrated by Figure 1 below visualizing central, decentral and distributed databases (Esmaeilian et al., 2020).

Figure 1: Overview of generic network type



Source: Adapted from Yogesh, Balamurugan, and Khan, 2020

Having outlined the conceptual differences between centralized in comparison to decentralized and distributed systems, in the following we will explore further the central

characteristics and theoretical concepts behind DLTs – namely the architecture of peer-to-peer networks, cryptography, consensus algorithms and smart contracts.

2.2.3 Peer-to-peer networks

"A peer-to-peer (P2P) network is a self-organizing arrangement of equivalent and self-governing elements that works for the use of shared, distributed resources in a network, which avoids a central authority " (Yogesh et al., 2020). This is in contrast to the client-server model, which operates with a client (for example the user) and a server (for example the NOVA university website) that the user connects to via the internet. The server is controlled by the NOVA administration team and the students can access the provided information. In a P2P network, there is no central server, but all the participants within a network are connected to each other, and information can be accessed and shared with each other as outlined by the P2P protocol (Yogesh et al., 2020). This eliminates a central entity and creates a network amongst peers to share and exchange information.

2.2.4 Cryptography

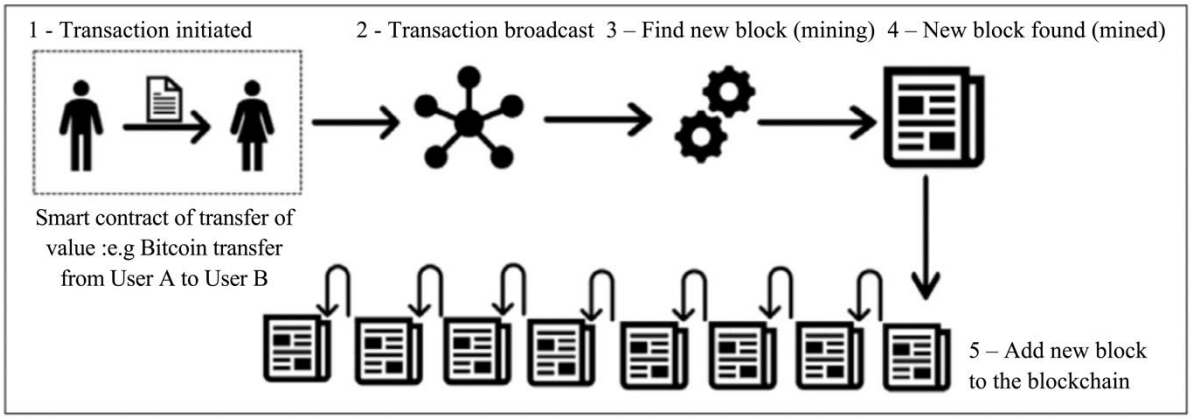
To ensure confidentiality and data integrity DLTs employ cryptography (Sunyaev, 2020). Asymmetric cryptography (or public key cryptography) consists of a set of keys - a private and a public key – which are mathematically related to each other. They are designed so that we can encrypt with a private key and decrypt with a public key and vice versa, we can encrypt with the public key and decrypt with the private key. The key feature of asymmetric cryptography is that the private key cannot efficiently be determined with the public key. This means that if the private key is kept secret to the individual user, the public key can be shared and two users unknown to each other have a mechanism to trust one another since this provides a kind of "digital signature". This also means all transactions can be made public since they only contain public keys and therefore, this information can be audited.

This set of private and public keys can then be used to create a tamper-proof digital signature using a cryptographic hash function, which „compresses a string of arbitrary input to a string of fixed length". Essentially, it allows a sender to decrypt a message with a receiver's public key, which only the receiver can decrypt with his private key, which ensures the confidentiality of the message. In a second step, the receiver can decrypt the contained message with the sender's public key to ensure the message has not been tampered with (because the properties of the hash function allow the correct message to be only returned if the public key is correct) (Sundaramoorthy, 2017).

2.2.5 Consensus protocol

In DLTs the record of information is distributed across a network of peers, where each has an identical copy with the ability to append new information. To ensure each participant in the network has an identical copy there needs to be a mechanism in place that helps the network to decide on the "truth". Every additional record needs to be audited for its validity and then distributed across the network to all nodes. The set of rules by which new information is added to the distributed ledger is called the consensus protocol – as the name suggests the protocol by which a consensus about the "true" information is reached amongst network participants.

Figure 2: Bitcoin Mining Process



Source: Bashir, 2020

2.3 Blockchain Technology

The previously presented conceptual frameworks of DLTs as well as their benefits and drawbacks, lay the foundational basis to explore further the blockchain technology, its applications, and how it can be adopted in a wide array of functions and industries. Blockchain is a type of distributed ledger system, so the frameworks and features described in the previous chapter build the base for this type of technology. In this chapter, we will further elaborate on the specific blockchain technology, its elements and characteristics.

2.3.1 Nodes

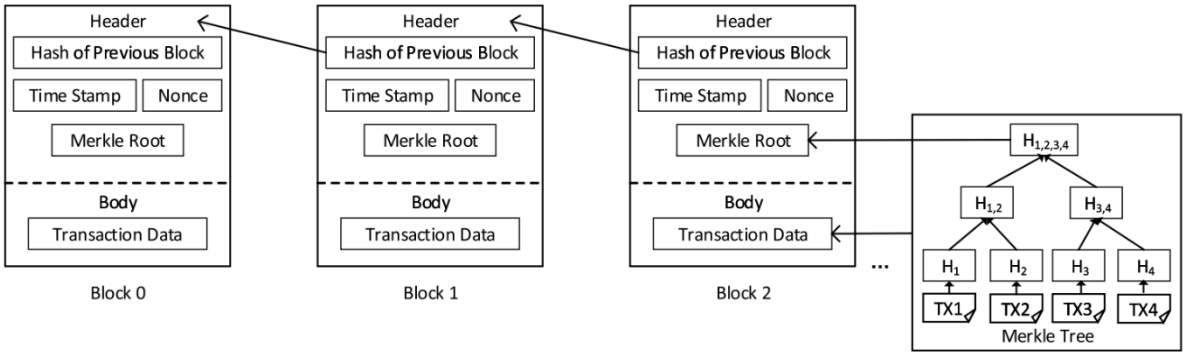
Blockchain as a type of DLT is a decentral and immutable ledger that is shared across a P2P network of equal participants, which are connected amongst each other (Tan et al., 2022). These participating computer on a network are called nodes and all of these retain an identical copy of the whole blockchain. Nodes are therefore an elementary unit to run and maintain a blockchain. Besides this, nodes are essential to validate the transactions contained in a blockchain according to the consensus algorithm and thus ensure the validity of the data. Not all nodes on a blockchain serve this validation function and some only store and broadcast data across the network. And finally, nodes represent the connection to the network to access information stored on the ledger. There are different types of nodes and with varying corresponding responsibilities and functions, however for the purpose for this thesis the concept of nodes as described above can be considered sufficient.

2.3.2 Block

Blocks are the basic data structure, that comprise the blockchain. As mentioned above blocks hold a set number of transactions that are pooled together into one block. A block is opened and records all new and unvalidated transactions until the given number of transactions per block is reached. These blocks are then closed, validated, and permanently added to the

blockchain. This process is repeated for all future transactions. Besides transaction data, blocks have additional information following a set structure, which is shown in Figure 1 below.

Figure 3: The structure of a Blockchain



Source: Liang, 2020, 123

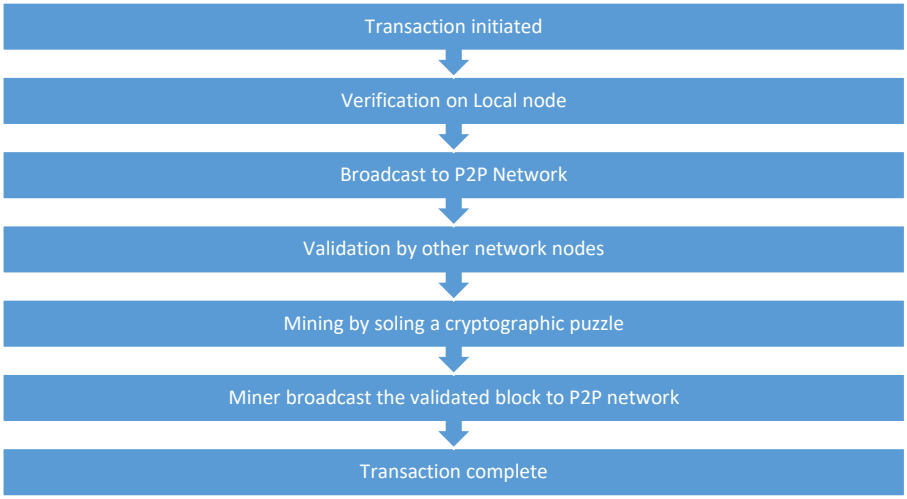
The hash from the previous block is engraved in the top of the header and functions as a connection to the previous block. A nonce (number used once) is part of and by adding it to the block the "hash output of the contents of the block will change" (Aggarwal et al., 2021, 152). It's part of the cryptographic puzzle that miners are solving in the proof of work consensus mechanism, which will be elaborated in the following chapters. For the purpose of brevity, the block structure will only be explained on a high level. The header of a block contains important metadata, such as the block version number, timestamp and mining difficulty.

2.3.3 Transactions

The most basic definition of a transaction is a "de facto exchange of value between [two] parties" (Bird, 1981, 272). A simple example is the purchase of bread in exchange for money. Similarly, a transaction in the context of blockchain is the transfer of value between two addresses. The value transferred can represent any asset, including cryptocurrencies but also

virtually any tangible and intangible assets. A set number of transactions of value between two parties are stored within blocks on the blockchain. To illustrate how a block comes into being, the transaction of the Bitcoin will be shown. It must be mentioned that the specific lifecycle depends on the use-case and specific blockchain details, but the fundamental principles apply.

Figure 4: Standard transaction lifecycle of a bitcoin transaction



Source: Adapted from Liu, Zhang, and Zhao 2022

The specific process of how a transaction lifecycle is executed varies in the specifics depending on the use-case and design of the blockchain protocols, however, the generic process steps on a high level can be summarized as follows. Figure 4 illustrates the process steps on the bitcoin blockchain network.

2.3.4 Types of Blockchains

Behind the term “Blockchain”, there are several different models that differ in terms of scalability, decentralization, identification of members, consensus mechanism, speed, amount of privacy, energy consumption, and fees (Ganne, 2018).

At its genesis, Blockchain was just a public access and completely decentralized technology (Nakamoto, 2008). Although nowadays this is the most known model, others have begun to emerge in recent years. Among these models, we can highlight private blockchains and Consortium blockchains. Another classification used to distinguish blockchains is based on permission to participate as a node in the network: "Permissionless" and "Permissioned" blockchains. Typically, people tend to associate that a public blockchain is always permissionless and a private/consortium blockchain is always "permissioned", but in reality, things can be slightly more complicated (Ganne, 2018).

Permissionless versus permissioned blockchains

A Permissionless blockchain allows anyone to install the ledger and copy the blockchain onto their computers, participating in the network as a node (Ganne, 2018). This kind of blockchain is transparent as anyone can read the transactions stored in the ledger at any given point in time (Solat et al., 2021). Bitcoin is the best example of what a permissionless blockchain is all about (Nakamoto, 2008).

In contrast, Permissioned blockchains act as closed ecosystems where only authorized entities can have access to the transactions history and download the ledger to perform as a node (Ganne, 2018). This type of blockchain is normally created by organizations that want to share secret documents among their own company or with others (Solat et al., 2021). This type of Blockchain is sometimes related to consortiums such as R3 or Hyperledger (Ganne, 2018).

Public versus private/consortium blockchains

The difference between public, private, and consortium blockchain remains in the management of the platform and in the level of anonymity of the users (Ganne, 2018). Each type has a different degree of decentralization, public blockchains are the most decentralized, and private blockchains are the least ones (Ganne, 2018).

Public Blockchains

Public blockchains are managed by a community, ensuring complete platform decentralization (Ethereum Foundation, 2015). All the information is public, and anyone can participate as a node in the network, by sending, receiving, and validating transactions (Yang et al., 2020). Since this type of platform doesn't rely on a third party to validate the transactions, the platform members are the ones responsible for validating them before any data is stored in the ledger (Ganne, 2018). This happens through a consensus protocol where nodes are compensated for participating in the network as validators. Bitcoin, for example, uses "Proof of Work" as a consensus protocol, meaning that all the nodes are competing to reach an algorithm that enables the possibility to unlock a new block (Nakamoto, 2008).

Private Blockchains

A fully private blockchain is a blockchain where write permissions are kept centralized to one owner (Ethereum Foundation, 2015). This owner has the power to decide who can read, write, or validate transactions in the network as well as decline transactions that are against the rules and regulations (Yang et al., 2020). A private blockchain allows for higher efficiency and considerably faster processing of transactions than public blockchains (Yang et al., 2020). This network uses much less computing power because the verification of the transactions is carried out by a relatively smaller number of nodes. Although these networks can provide more privacy to users, they are less robust and unprotected against external attacks (Ganne, 2018).

Consortium Blockchains

As Vitalik Buterin said in 2015, consortium blockchains are a type of private blockchain where the consensus process is controlled by a pre-selected set of nodes (Ethereum Foundation, 2015). They can perform some activities such as writing and reading data from

the blockchain, along with deciding who has access to the ledger. The members of the consortium can decide if access to the data is public or restricted to the participants (Ethereum Foundation, 2015).

Consortium blockchains enable documentation transfer between member companies in a secure way (Dib et al., 2018). For example, in a consortium blockchain managed by 5 companies, if Company 1 only transacts and shares its documents with Company 2, it can be decided to grant these companies exclusive access to see the shared data (Ethereum Foundation, 2015). This prevents enterprises not involved in the transactions from having access to secret documents despite belonging to the same consortium network (Ganne, 2018). This type of network was an innovation that allowed to leverage connections between partner companies using blockchain technology.

2.3.5 Qualities of Blockchain

Blockchain technology is most known because of its crucial role in the cryptocurrency systems, such as Bitcoin. As a shared and distributed ledger, Blockchain has several qualities, presented above, that can be used to bring solutions not only for the end-users but also for companies.

Security and Immutability

Hash functions are used to cryptographically protect each new block on a blockchain, and each time a new block is mined, the blockchain is updated with the rest of the network (Yassein, 2019). Once acknowledged by the community, the data stored on the blockchain cannot be changed or updated, becoming immutable. (Hofmann et al., 2017). This is because, after being approved by the community, the data is stored in a block that is connected to the preceding block by a code known as a hash (Hofmann et al., 2017). Since the blocks are interconnected through hash functions, to change the information of each block it would be

necessary to have control of more than 50% of the network, which is not feasible due to the computational power that such a takeover would require (Bae & Lim, 2018) . This means that as a network grows, it becomes harder to change any transactions that are kept on its blockchain, thereby reducing the likelihood of fraudulent transactions (Yong & Yannan, 2018).

Persistency and Anonymity

The consensus mechanism used by the blockchain makes it possible to validate transactions rapidly and identify transactions that might be harmful to the network (Zheng et al., 2017). Sometimes nodes can validate fraudulent transactions, allowing them to enter the blockchain. These transactions are simple to identify thanks to the blockchain's capacity to follow its records, and the node that made them can eventually be banned from the network (Zheng et al., 2017). Despite being easily identifiable, these nodes may not have their true owners' identities revealed due to the blockchain network's inherent anonymity (Zheng et al., 2017).

Transparency and Verifiability

Blockchain is a technology known for its transparency, as all transactions stored in the distributed ledger can be seen by all members of the public network (Li et al., 2020). That is, all transactions accepted by the community through the consensus protocol are assigned to a time or date of creation, being easy to access them no matter how big they are (Hayes, 2022). Since every node has its own copy of the blockchain ledger, it’s almost impossible for a transaction to be lost in the network (Yassein, 2019). All the records stored in the blockchain remain encrypted and anonymous until the owner wants to decrypt it and reveal its identity by using a public-private key pair (Yassein, 2019). Even if the owner of the transaction is anonymous, it is possible to trace the transaction from its creation through the public key, ensuring anonymity while preserving transparency (Hayes, 2022).

2.4 Blockchain use cases and impact

2.4.1 Cryptocurrencies

A cryptocurrency is a type of digital currency that uses a computer network to function as a means of exchange and is not backed or maintained by any single entity, such a bank or the government. The ownership information for each currency is kept in a digital ledger, a computerized database that employs strong encryption to safeguard transaction records, regulate the production of new coins, and confirm ownership transfers. Despite their name, cryptocurrencies are not understood to be currencies in the conventional sense. Although they can be used to classify assets in a variety of ways, including as commodities, securities, and currencies, in actuality these assets are typically seen as a separate category in and of themselves. This is due to the fact that cryptocurrencies are not guaranteed by a government, nor are they governed by financial institutions. Although Bitcoin was the first cryptocurrency in operation, there are other more varieties and iterations of cryptocurrencies. It is possible to categorize cryptocurrencies into at least four separate groups based on its creation or code design, application or use case, and other factors.

In a blockchain, a token is a digital representation of a certain asset or utility. All tokens can be referred to as altcoins, however they vary from one another by being on top of a separate blockchain and not being a part of that network natively. As a matter of fact, Tokens are cryptocurrencies that do not have their own blockchain but live on another blockchain, benefiting from its technology accordingly. Since some of them are configured to enable smart contracts on blockchain networks like Ethereum, it is possible to move them from one chain to another. Additionally, because tokens are built into self-executing computer programs or algorithms, they may operate independently of a third-party platform, and they can act as substitutes for goods, rewards, or even other cryptocurrencies (Kathy Brooks, 2022).

2.4.2 Ethereum

Created in 2015, Ethereum was created entirely through the influence of bitcoin. The purpose of Ethereum was to maintain a blockchain platform that consisted of a consensus network (proof of work), while allowing developers to take advantage of this technology and create their own applications. In other words, the main difference is that Ethereum to that of Bitcoin is its programmability (Ethereum Organization, 2018). As a developer, you can create your own programs and applications on Ethereum, "while benefiting from the decentralization and security properties of blockchain, and particularly avoid the need to create a new blockchain for each new application" (Buterin, 2016). As a result, Ethereum's platform is similar to that of a marketplace, providing financial services, social-networking, games, and applications. The primary asset on the Ethereum network is ether (ETH) and it cannot operate without it. This is because whenever you transfer or use an Ethereum application, there is an ETH fee attached to the transaction.

At the top of the chain are the decentralized applications (dApps). According to Ethereum.org, there are four categories of dApps (Finance, Arts, Gaming, and Technology) where ether is the lifeblood (Cryptopedia staff, 2021a). Decentralized finance (DeFi) permits individuals to borrow, lend, invest, and send payments all around the world with security and anonymity. Decentralized art deals with collectable tokens, also known as NFTs. Decentralized gaming is similar to that of any other conventional game, with collectables and real-world value involved. And finally, decentralized technology, where developer tools or existing technologies are incorporated with decentralization (Ethereum, 2022). At the core of these applications are what are known as smart contracts, i.e., programmable agreements.

2.4.3 Non-Fungible Tokens

To understand what NFTs are, it necessary to first start with the concept of non-fungibility. NFT. In fact, stands for non-fungible-token. This means that the token, that is the asset containing the image within it, is unique and cannot be exchanged for another identical token. This happens because each non-fungible token is created with a unique internal code written on blockchain, which is visible to everyone. The creator of this particular type of token will enjoy ownership rights, and his or her name will pop up inside the blockchain when you go to view it (Hamilton, 2022).

In this huge marketplace users exchange exclusive tokens with each other in exchange for cryptocurrencies, especially Ethereum. As said before, NFT is unique, and it cannot be exchanged in any way with other similar tokens, except for cryptocurrencies. Each non-fungible token contains a certain amount of information within it, which is then reproduced in the form of an image, video or custom content. Their value, on the other hand, is determined primarily by the market and demand, making them comparable to any other type of artwork, in this case digital art.

2.4.4 Smart Contracts

Smart contracts are programmable scripts that are stored on a blockchain or other decentralized network that automatically transfer digital assets when certain pre-specified conditions are met (IBM, 2022). These conditions are agreed upon and validated by the community and stored transparently on the blockchain, avoiding trust issues between the members of the blockchain.

Nick Szabo, an American computer scientist and cryptographer was the first to introduce Smart contracts – back in 1994 (Nick, 1994). According to Szabo, the basic idea behind smart contracts is that “many kinds of contractual clauses (such as collateral, bonding, delineation

of property rights, etc.) can be embedded in the hardware and software we deal with, in such a way as to make a breach of contract expensive (if desired, sometimes prohibitively so) for the breacher" (Nick, 1994).

How Smart Contracts work - To understand how smart contracts work technically, it is essential to understand first how the first blockchain to support their execution works - Ethereum Blockchain. The basic unit of Ethereum is the account, and the main function of the network is to track the status of each account (Buterin, 2014). Whenever there are changes between accounts, through exchanges of value or information, the Ethereum blockchain updates the state of each of the accounts to balance the network (Buterin, 2014). There are two types of accounts in the Ethereum blockchain: Externally owned accounts (EOA) and Contract accounts. EOAs are controlled by humans through their public-private key pair; their address is determined from the public key (Buterin, 2014). Contract accounts are controlled by their internal code and can only be activated by an EOA (Law et al., 2017).

Smart contracts can be applied to solve more complex problems such as the optimization of a company's supply chain, but they can also be applied to more mundane activities such as the processing and payment of employees' salaries (Ante, 2021). Figure 1 demonstrates how smart contracts can be used for the automatic processing of salaries.

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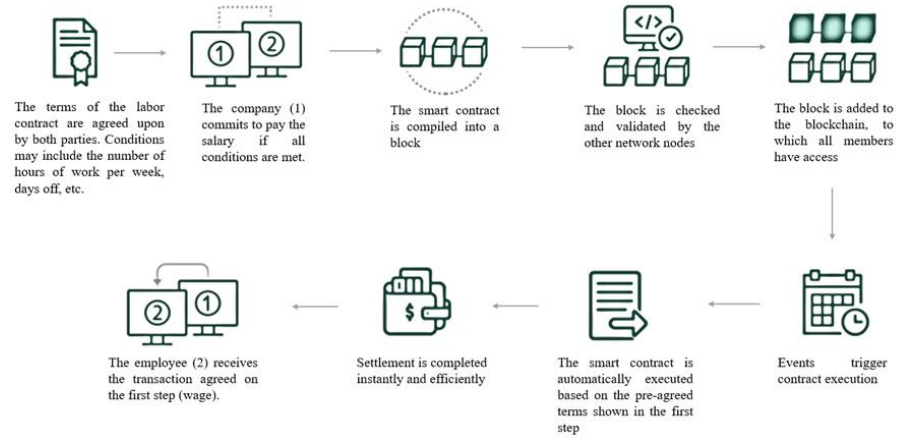
Figure 5: Practical smart contract application



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Source: Own illustration

Users must use an EOA to conduct a transaction with a Contract Account in order to start a smart contract (Buterin, 2014). The transaction is encrypted using the private key of the initiator's account and then sent to all network nodes, in this case, the Ethereum blockchain (Buterin, 2014). To ensure the authenticity of the transaction, the other nodes need to approve it by accessing it through their public key (Smart Contracts Alliance, 2016). Once approved by most nodes in the network, the transaction is stored in the blockchain, the smart contract is ready to be executed and its outcomes are stored forever in the blockchain (Law et al., 2017).

All transactions that change the state of the Ethereum network, for example, the execution of smart contracts, require the use of Ethereum Virtual Machine computing resources (Buterin, 2014). The use of these resources has a cost, so each initiator of a transaction must pay a fee in Ether for the transaction to be executed (Buterin, 2014). The value of the fees will depend on the amount of computing power used as well as the amount of memory needed to store the transactions (Law et al., 2017). This was a measure taken to encourage the Ethereum community to create the most code-efficient transactions possible.

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Challenges

Although smart contracts have a varied set of benefits and potentials, there are some risks associated with them. Smart contracts cannot be activated on their own, without some external event happening to trigger the execution of the code embedded in the contract. One of the challenges of this technology is the lack of capacity to deal with external events that happen off-chain. While smart contracts can automatically execute their code after an on-chain event, the same is not possible when the triggering action occurs off-chain (Ante, 2021). Although the blockchain offers a secure environment, it's possible that smart contract participants won't trust the data sent to the blockchain, when an off-chain event occurs. This limitation is known as the oracle problem (Ante, 2021). Another challenge of smart contracts has to do with the scalability of the technology itself. This scalability depends on the efficiency of the integration of traditional systems with blockchain. Ensuring interoperability between systems is key to ensuring that no information is lost (Law et al., 2017). Today, smart contracts are very complex to implement and require deep technical knowledge in the area of web 3.0 (Wong, 2022). Finally, one of the biggest challenges that smart contracts are facing today is the lack of regulation (Law et al., 2017), which can leave users vulnerable to fraud and other malpractices.

DAO Project: An example of smart contracts fragilities

The DAO project pioneered the creation of an organization governed by rules and bylaws of an entire organization, encoded in a smart contract (Buterin, 2014). This Ethereum blockchain project was central to understand the limitations of smart contracts and was an important part of the Ethereum community's ongoing process of improving this technology.

The DAO plan was to create a virtual venture capital fund where investors could decide how the money should be used. They would be compensated with dividends based on the success of their investments. This project at that time was the largest crowdfunding event made raising 11.5 million Ether, valued at 150 million dollars (Dino, 2016).

However, in June 2016, a bug was found in the smart contract's code that allowed a hacker to steal about a third of the funds. A hard fork of the Ethereum network into the two blockchains Ethereum and Ethereum Classic was caused by the incident. While no changes were made to Ethereum Classic, The DAO and the hack were unwound on Ethereum (Dino, 2016). The money taken from The DAO was returned to its investors and saved in the Ethereum Classic chain. This case shook the Ethereum community and triggered several discussions about this emerging technology.

2.5 Technology adoption models

2.5.1 Technology acceptance model (TAM)

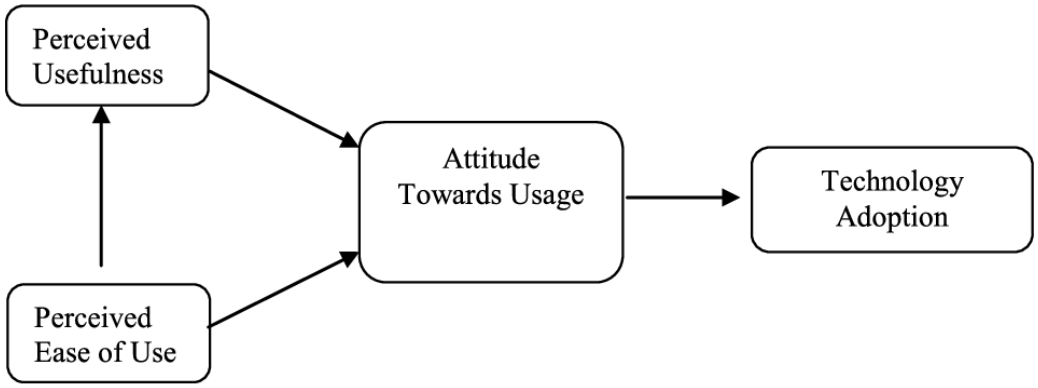
The technology acceptance model (TAM) is a theoretical model used to explain and predict an individual's adoption and use of technology. The model was developed by researchers at the University of Minnesota in the early 1980s. Although it was first applied by Fred Davis, Richard Bagozzi and Warshaw (1989). Since then, is TAM has been extended and applied to a variety of different technologies and contexts, including computer software, websites, and

mobile applications. This model was designed for the purpose of helping to explain how users use a particular technology, and also to understand and predict user perceptions of using the technology.

In fact, the original TAM model proposed two key factors that influence an individual's adoption and use of technology: perceived usefulness and perceived ease of use. Perceived usefulness refers to the extent to which an individual believes that the use of a particular technology will help him or her achieve their goals. Perceived ease of use refers to the extent to which an individual believes that the use of a particular technology is easy to use.

Subsequently, the TAM model was expanded to include a number of other factors that may influence an individual's adoption and use of technology. These factors include perceived risk, social influence, and perceived pleasure. Respectively, perceived risk is the degree to which a person believes that the use of a particular technology may lead to a negative outcome in general. On the other hand, social influence is the degree to which a person is influenced by others in making a decision about whether or not to use a particular technology. For example, the more people adopt a particular technology, the more likely an individual will be to choose it over another. As the third and last, we find perceived pleasure, which represents the degree to which a person believes that the use of a particular technology is enjoyable/fun.

Figure 6: TAM Model



Source: Davis, 2018

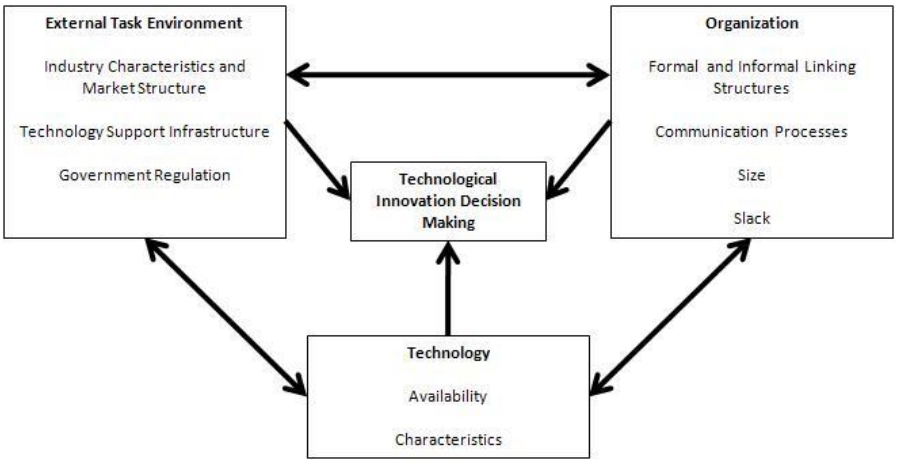
Computer systems, office equipment, and information systems have all been adopted and employed, and TAM has been used to explain and anticipate this. TAM has been specifically used in recent years to evaluate the acceptance and use of blockchain technology.

In reality, a rising body of research contends that TAM may be used to forecast and explain the uptake and application of blockchain technology. For instance, a 2018 study discovered that perceived utility and perceived usability are both important determinants of blockchain technology acceptance and use (Drosatos et al., 2018). Similar to this, a 2017 study by Kiviat discovered that perceived utility, not perceived ease of use, is a strong predictor of acceptance and use of blockchain platforms (Sciarelli et al., 2022). This is mostly because blockchain technology is still in its infancy and is not well understood by the general public. It is also because other criteria, such as perceived utility or perceived danger, may be more essential for blockchain technology than perceived ease of use.

2.5.2 Technology-organization-environment model (TOE)

Originally described in Tornatzky and Fleisher's "The Processes of Technological Innovation" (1990), the technology-organization-environment framework, or T-O-E, is a framework that should be considered by organizations with regards to technology adoption and implementation (Baker, 2011a). As an organizational level context theory, the T-O-E consists of three segments that should be considered: the technological aspect, the organizational aspect, and finally the environmental aspect. The combination of these three segments provides basis for technology adoption and implementation.

Figure 7: Technology-organization-environment framework



Source: Baker, 2011

Technological Context: Within the T-O-E framework, the technological context describes all of the technology that is relevant to the firm (Baker, 2011). The technology can already be in use within the organization, or it may exist outside the organization and its implementation may be forthcoming. Internally, the framework provides insight on which technologies are currently in place, demonstrating the limits of technology in-place and the current transition capabilities that the company itself can undergo. External technology provides insight on what limits are bound for innovation given the current marketplace, along with influencing new ideas to evolve current in-house technology (Baker, 2011). Certain elements of the technology factor include and are not limited to complexity, compatibly, relative advantage.

Organization Context: Organization context within the T-O-E framework outlines the various structures within an organization and how particular structural methods may prove more adequate in regards to technology adoptions than others. As an example, "organic and decentralized organizational structures are associated with adoption", while "[mechanistic structures] … emphasis on formal reporting relationships, centralized decision-making, […], may be best-suited to the implementation phase of the innovation process" (Baker, 2011a).

Other factors that should be considered within the organization realm include communication processes, slack, and size (Baker, 2011). In terms of communication, research has demonstrated that higher levels of transparency between departments within an organization (particularly R&D, marketing, production) influences higher levels of innovation (Kivimäki et al., 2000). On the other hand, there appears to be less correlation between firm size and innovation: "…there seems to be little empirical support for the view that large firm size … are factors generally conducive to a higher level of innovative activity"(Symeonidis, n.d.).

Environmental Context: Similarly, to the organizational context, technological adoption and innovation can be accelerated or hindered due to the environmental structure surrounding the firm. This includes, "the structure of the industry, the presence or absence of technology service providers, and the regulatory environment" (Baker, 2011). Addressing the first point, elements such as competition and industry life cycle play an important role. Higher competition would influence the need for innovation, and this logic is similarly applied to firms growing in a fast-paced industry (Baker, 2011). That said, competition only provides a positive influence towards innovation towards 'neck-and-neck' firms, rather than the so-called *laggards* (Aghion et al., 2005). In terms of technology service providers, firms that require for skilled workers tend to invest more in cheaper innovative solutions. Finally, governments, along with their policies and regulations can prove to be beneficial or harmful to the organizations.

Limitations and criticism

Although used widely in the research community, the T-O-E framework is not without its limitation. As a start, the framework has made little improvement since it was first developed in 1990 – the framework itself is highly adaptable and can be used in diverse contextual settings. Hence, flexibility provides less incentive to modify the theory (Baker, 2011). Another

limitation to its evolution may be how closely tied the framework is with other theories, namely the diffusion of innovation theory (DOI) (David Bryan & Zuva, 2021). In all three aspects of the T-O-E, similarities to the DOI theory can be identified, and as a result their interaction results in collaboration rather than separation. That said, there has been criticism on how the framework lacks other variables that cannot be explained by its current factors, e.g., technology readiness, security concerns, culture, cognitive variables, etc. (David Bryan & Zuva, 2021). As examined the T-O-E framework provides insights on technology adoption, given a firm's technology capacity, organization, and environment. Along with a qualitative and/or quantitative methodology, researchers gain the capacity to make informed decisions while taking into account risk and areas of importance.

3 Methodology

To answer the research questions, this thesis primarily uses a qualitative research approach with the primary data consisting of eight semi-structured expert interviews. This is complemented with case studies based on the interview and is enriched with secondary data as well as academic literature. Qualitative research methods are suitable to take an exploratory approach to answer the relatively novel field of blockchain technology and its application and implementation across the private and public sector (Lustenberger et al., 2021). The case studies further allow an in-depth perspective of real-life applications and is an insightful tool to conceptualize to generalize that may help inform future IT and blockchain projects (Basias & Pollalis, 2018).

3.1 Data collection and sampling

Primary data in the form of interviews will be the main source of insights generated in this work. Due to the novelty of this technology and the subsequent scarcity of information on blockchain adoption, it was vital to gain an insight from experts on the topic from a range

of perspectives. Intentionally, the criteria for interviewee selection are designed to be broad enough to capture a wide variety of perspectives and aspects. The participants have more than >3 years of relevant blockchain experience pertaining to the respective chapter of this thesis. Relevant experience is any involvement in the implementation of a blockchain solution from a customer perspective (e.g., companies), from an IT-services provider perspective (e.g. consultants, developers, project managers) or from an outside-in perspective with a focus on such area (e.g. knowledge consultants, academics). Interviewees are selected based on these criteria and their knowledge relating to a specific chapter of this thesis, however the insights are shared, and synergies are leveraged for all chapters wherever appropriate and possible.

3.2 Interviews

As a theoretical framework for technology adoption this study is inspired by the TOE framework, however, it is not constraint to it in line with the exploratory approach of this paper. The interview was therefore initially structured based on the TOE framework, but expressly provided enough flexibility to appropriately follow the insights shared by expert interviewees. To ensure the integrity of this research and to establish for a common consistent research approach a guideline with guidance and clarifications was developed internally (Appendix 10.5). The primary qualitative data for analysis is the interview transcripts.

3.3 Qualitative Analysis

The research approach is based on analyzing the interview data focuses of the in-depth qualitative interview transcripts. Through this approach, key themes and topics will be identified, and compared while also noting patterns and relationships between different aspects of each. themes will be identified by the research team, based on the interview

transcripts, and then further analyzed and interpreted. This analysis process involves rereading of the transcripts to ensure full comprehension of the data.

3.4 Quality criteria of qualitative research

To ensure the integrity of this research paper, the quality criteria as defined by Bryman et.al. are employed to assess and guide the research process, namely credibility, transferability, dependability, and. Confirmability (2008). These will be briefly defined in the following, and the implementation in the context of this thesis will be outlined.

Credibility is the extent to which the research findings are believable and trustworthy. This is achieved by conducting the research in an ethical manner and by collecting data from reliable sources (Bryman et al., 2008). For this paper to ensure that the data collected is credible was ensured through peer debriefing, careful selection of interviewees and triangulation with additional primary and secondary sources. Confidentiality was achieved by anonymizing the interview transcripts, without compromising the quality of the primary material for analysis. The evaluation criterion of transferability describes the degree to which the research findings can be applied to other contexts (Bryman et al., 2008). For this thesis, it was ensured that the context in which the expert interviews were conducted was made transparent to allow the reader to make a judgment about the transferability (Appendix). This criterion was met only to a limited extent, given the exploratory nature of this thesis. The dependability of the data gathered from the interviews was ensure by employing a range of sources. The primary data was complemented with a thorough literature review and additional scientific sources. This also aims to fulfill the criterion of confirmability, which describes the extent to which the research findings are consistent with other sources of evidence Bryman et al., 2008). This was only possible to fulfill to a limited extent, as the research areas is only scarcely researched.

4 Application to International Maritime Supply Chains and Cross-border Trade

4.1 Introduction

This chapter will analyze how blockchain can be used to facilitate the secure transfer of documents along maritime supply chains, and thus contribute to a reduction in shipping times. To this end, the analysis will begin with an overview of the current international trading system flows. The second part will present a study on the adoption of blockchain in Portuguese maritime supply chain companies (MSC). Based on the TOE framework, this study will point out the advantages that this technology can bring to MSC companies in Portugal, but also the main obstacles that they will face in its implementation. Finally, in the third part, a successful case study of a blockchain platform applied to this topic will be analyzed.

4.2 Theoretical Framework: International Trading System

4.2.1 Logistics Flow

The logistics flow is responsible for guaranteeing that cargo is delivered on time to the importer, requiring almost perfect coordination between all participants in the maritime supply chain. The maritime supply chain (MSC) consists of three main parts: shipping, port operation, and freight forwarding. **Shipping** is the act of moving goods from one port to another. In the current system, shipping companies also provide other different services such as pick-up service, delivery notification, inbound/outbound bill of lading (B/L), container tracking and information, and intermodal services (Eon-Seong & Dong-Wook, 2010).

The main role of the **ports/terminals** is to load/unload the vessels, preparing the cargo to be sent to the port of destination. They play a fundamental role in linking land logistics to maritime logistics, being a critical stage in the process of transferring cargo between countries.

In addition, ports often accumulate other functions such as warehousing, storage, and packing (Stopford, 2009).

Often given the complexity of the transport process between countries, a third intermediary is added to speed up the whole process - **Freight forwarders**. Freight forwarders mediate the hiring of vessels and other services related to import and export, negotiating rates with shipping companies (Deloitte, 2019). Apart from that, freight forwarders might also prepare requisite documents for ocean carriage, customs clearance, and/or insurance requirements.

4.2.2 Document flow

Executing transactions in cross-border trade requires a wide range of documents that enable the transportation process to be unlocked. Between the various documents required, the most relevant are defined in table 1 of the appendix. Among these documents, two stand out based on their relevance in the process of exporting and importing cargo: **Letter of Credit and Bill of Lading**. The first will be discussed later in the cash flow section. The Bill of Lading (BL) is the document that allows the importer to collect the cargo from the shipper, serving as a receipt for the shipped products (Klenton, 2019). The document details the type, quantity, and destination of the goods being carried and represents the agreed terms and conditions for cargo transportation (Klenton, 2019). The BL remains with the exporter until the importer transfers the monetary amount initially agreed upon for the cargo. The figure 1, in the appendix, shows how some key documents are transferred across global supply chains.

4.3 Cash flow

To understand the international trade process, it is crucial to walk through the money flows between the exporter and importer and one special intermediate – the bank. Banks make sure that the importer pays the exporter the agreed value of the goods, by issuing a letter of credit (L/C). L/C is a document that proves that the importer will pay his debt to the exporter at the

agreed time (Chang et al., 2019). This is the safest payment method because the bank by issuing this document is responsible for paying the importer's debt in case of default. To protect against the danger that the issuing bank would fail to pay, the exporter may have a bank (advising/negotiating bank), in its own country, confirming the L/C. The figure 2 in the appendix illustrates a normal L/C payment process in the international trade industry (Chang et al., 2019).

4.4 Blockchain adoption across Portuguese maritime supply chain companies

The second part of this chapter will provide an analysis on the adoption of blockchain technology by Portuguese companies in the MSC. Several companies were chosen from the maritime transportation sector, given that it accounts for 90% of international trade (OECD, n.d.).

Three semi-structured interviews with Portuguese shipping businesses and blockchain professionals in Portugal were conducted for this study. The first participant (Interviewee A) was a cloud services director for a large technology enterprise with substantial expertise in developing and implementing blockchain initiatives on a European scale. This first interview focused mostly on the technical elements of blockchain, emphasizing the primary benefits and drawbacks that it might offer to Portuguese enterprises. The second participant (interviewee B) was the director of a Portuguese maritime cargo transport firm with no blockchain expertise. This conversation focuses on the present status of the Portuguese shipping industry, emphasizing the major challenges that companies in this sector confront while introducing new technologies. Finally, the third participant (Interviewee C) was a logistics director responsible for the import of goods to Portugal, who despite not working with blockchain on a regular basis has extensive knowledge in the area. In this interview the current state of the maritime transport sector and how blockchain can solve the main problems of this sector were

addressed once again. Additionally, the TOE framework was also used to point out the main obstacles that Portuguese companies face in adopting technologies such as blockchain, having use some scientific papers, to fill in some information that was not provided by interviewees.

4.4.1 Technological context

The technological context covers the internal and external technologies available to an organization, i.e., those that are already used by the organization and those that are available but have not yet been adopted (Cruz-Jesus et al., 2019). Technology plays a key role in maritime supply chains. Most organizations across the industry rely on software to manage their operations, such as the tracking of containers or the storage of trade documents.

The fact that each organization has a different software from the one used by its stakeholders, creates a communication barrier between them. Since cargo documentation needs to be sent, after confirmation, to the various intermediaries in the supply chain (SC), it is essential to have a solid bridge between them for trade to flow smoothly. Although some of the documents are already digitized, they are not transferred digitally among intermediaries due to system heterogeneity across the industry (Jensen et al., 2019). This challenge can be solved by applying blockchain technology. Through this technology, all the intermediaries in the SC involved in the transport of cargo, between the producer and the end consumer, can be interconnected on a single platform. These blockchain-based platforms allow the sharing of data/documents and information regarding the movement of cargo, making it easier to track and estimate the shipping time. For this to be possible the players in the MSC would have to integrate their traditional software (legacy system) with the blockchain, which although possible is still a complex task.

Hypothesis 1: Systems integration consist of a barrier in blockchain adoption

Throughout the interviews, the capability of blockchain to integrate with traditional systems was highlighted as one of the technical obstacles that Portuguese firms might face. Since the blockchain system is distributed, its characteristics differ greatly from traditional systems, making the connection between them complex, as stated by Interviewee A.

According to this interviewee (A), in a distributed system each of the nodes performs similar tasks. This happens to ensure the resilience of the network because if one goes down, there are others that can replace its functions automatically. Usually, the decisions made in these networks are in consensus among all nodes. In a traditional system, the network is centralized which impacts the way transactions are processed and executed. These traditional networks execute each transaction only once by responding through a one-way function, i.e., when any participant in the network makes a request, they only get one response. Whereas in a blockchain system when a request is made all the systems nodes will respond. So, there is a dichotomy: while a blockchain system executes the same request n times, a traditional system cannot interpret that same request more than once. It is complex to create a gateway that connects these two types of networks. Although these gateways exist, they are complex, which means that companies need to study these solutions before implementing them, which involves a significant investment not just financially but also in time.

Hypothesis 2: Traditional systems are efficient in tracking cargo and discover counterfeit items

According to interviewee B, in recent years MSC companies, in Portugal, have invested in new technologies to facilitate their work. Regardless of this investment, the industry still faces a problem with the ability to track the cargo it transports. For example, it takes days to trace the provenance of a counterfeit product, as it is necessary to search through several waybills

and delivery notes for an error. This topic constitutes another branch of action of blockchain's application to this industry. In this situation, blockchain and its related tracking capabilities may offer a complete audit trail of transaction data for each SC touchpoint and enhance the product line with verifiable, transparent, and unchangeable records in the form of digital certificates. In order to combat counterfeit goods, it will provide customers, governments, and companies with irrefutable verification of the provenance and legitimacy of items. This solution might be a factor that can lead companies, in the maritime supply chains adopt blockchain technology.

4.4.2 Organizational context

The organizational context comprises the different features of an organization that influences the decision of adopting a new technology (Cruz-Jesus et al., 2019). The company's size, hierarchy, and top management support are examples of these features.

Hypothesis 3: Company's size matters

As stated by Interviewee C, the Portuguese business environment is composed of about 99.9% SMEs, with only 0.5% being medium-sized companies. Based on these numbers, both interviewees A and C, agreed that the size of companies is a major barrier to blockchain investment in Portugal.

Portugal has many small companies and few large companies, so there is no "sweet spot" with a significant number of medium-sized companies. Since they don't control a significant portion of the market, medium-sized companies' priority is the minimization of costs, as said Interviewee A. These enterprises are the ones that would have more benefits in sharing their data and forces on a common platform powered by blockchain.

Larger companies, in theory, have more financial resources to invest in this technology but they are limited by an ecosystem rounded by small companies, that do not have sufficient monetary resources to invest in this kind of innovation. Therefore, even for some large Portuguese firms, it is quite complicated to create a blockchain ecosystem that involves all its stakeholders. For these companies, the investment can end up not paying off also because of the changes that would have to be made in the way of working. Several companies working on the blockchain means having to work at the pace of the slowest partner, with necessary agreements between every stakeholder. These blockchain projects are more time-consuming and require a huge amount of effort from all parties involved. For these reasons, the heterogeneity of the Portuguese business environment was pointed out by Interviewee A and C, as one of the biggest obstacles to the expansion of blockchain-based ecosystems in this country.

Hypothesis 4: Lack of distributed systems technicians in Portugal influences blockchain adoption

According to interviewee A, in Portugal, there is a good foundational base in terms of distributed systems. Universities and companies are investing more in technological education, “producing” a lot of good technicians and engineers that are then hired by multinational companies. Many of these companies end up establishing themselves in Portugal, and the existence of workers with high qualifications in this area is an important factor for this to happen. These technicians and engineers in Portugal represent a younger generation, and there is still a conceptual gap between them and the current top executives of MSC firms. Therefore, the difficulty in finding high qualified technicians in the blockchain area should not be an impediment to Portuguese MSC companies adopting blockchain solutions.

Hypothesis 5: Top management support and mentality matters

During the interviews, one of the interviewees stressed the importance of knowledge about new technologies by top managers. Interviewee B stated that nowadays top managers are more open to the adoption of new technologies. This openness was not a characteristic of top managers a few years ago in the maritime supply chain industry, so there has been a positive evolution in that direction. Despite this evolution, the lack of knowledge about blockchain technology is still a huge obstacle for these companies.

Although there has been an evolution in the last few years in this area, the mentality of Portuguese companies in the MSC industry is still very traditional. Interviewee C referred that, there is still a lot of mistrust in the sharing of information between companies and their stakeholders. This mistrust tends to be more prevalent in smaller companies, where they still share the opinion that "secrecy is always the soul of business". The principle of using blockchain in the business environment is precisely the opposite, i.e., sharing information and efforts to jointly help each other. In this regard, there is still a long way to go before Portuguese businesses realize that working together will be far more advantageous than doing it independently. Only by investing in blockchain education can Portuguese firms overcome their outdated thinking. According to Interviewee C, larger enterprises with government support, should sponsor education in this subject so that small businesses will be fully able to decide whether or not to embrace blockchain technology.

4.4.3 Environmental context

The industry's organizational structure, the existence or lack of technical service providers, relations between competitors and suppliers, and the regulatory environment are all examples of analyses that should be made in the environmental context.

Hypothesis 6: Overcoming the trust issue between SC stakeholders

Trust and commitment between SC stakeholders are very important factors in cross-country trade, but currently, they also correspond to the biggest challenges in the maritime supply chain industry, as stated by Interviewee C. According to the second participant (B), the use of false documentation such as BLs is a contributing factor to the loss of trust among stakeholders. In the current system, SC stakeholders rely heavily on intermediaries (e.g., banks and legal entities) to verify, authorize and coordinate transactions. Every single one of these middlemen often gets a cut, which raises the price of goods transportation.

Given its characteristics, blockchain technology presents itself as a possible solution to the trust issue. Through this technology, different stakeholders can carry out transactions securely on a sharing platform. The truth is secured by cryptography and consensus algorithms. As a result, it is possible to verify and audit any transactions or information in real time, including the parties' credentials and reputation as well as the characteristics of the associated goods or services (Y. Chang et al., 2019a).

Hypothesis 7: Regulatory environment influences the adoption of blockchain

The existing regulation in each country is an important point when analyzing the adoption of a disruptive and recent technology such as blockchain. In Portugal and in many EU countries, the lack of legislation and regulation on the blockchain is still a point of discussion. According to interviewee A, EU countries are behind others, like Dubai, in the creation and implementation of legislation about blockchain and smart contracts. This occurs because all member states must agree on the adoption of common laws before each country may translate the European law into its national law. Companies are wary of utilizing blockchain technology because of the delays in the development of regulatory processes. According to interviewee A, political will is not the only factor responsible for the creation of legislation on new

technologies. Referring to an example that took place in Portugal a few years ago about the adoption of digital signatures, interviewee A pointed out that the pressure implemented by foreign companies is one of the drivers for the creation of new legislation. These companies, by complying with advanced laws from their origin country, started to introduce new technologies in Portugal gaining an advantage over the local companies. This case has put more pressure on the government to speed up the process of creating laws on this matter, showing that sometimes is necessary a little push from the market.

Another important aspect regarding legislation is to make sure that the same is revised on a regular basis to keep up with normal technological growth. Currently, there are some organizations, like the EU, that continue to demand the presentation of the original documents—i.e., actual paper documents with stamps and signatures (Jensen et al., 2019). While the containers are being transported by sea, these documents are being transferred through air couriers. According to respondent B, there is no one standard in Portugal for all customs authorities, some of the country's customs accept digitized papers while others don't. This type of regulation slows down the whole shipping process because a container can be held back and delayed for days or weeks by an inaccurate printed document (Chang et al., 2019b). In this case, blockchain could contribute to the full digitalization of maritime supply chains by creating digital versions of existing documents, such as the BL and L/C. These documents could be stored and shared among the various network participants in a matter of seconds. Thus, this is a case where outdated legislation prevents Portuguese supply chain companies from operating one hundred percent with digitized documents.

4.5 Case Study – TradeLens

TradeLens is a blockchain-powered digital platform that promotes efficiency, transparency, and collaboration in global supply chains (TradeLens, 2019). Every participant in the supply

chain, including shippers, freight forwarders, ocean carriers, ports and terminals, customs authorities, and financial services providers, may access and manage shipping data using TradeLens' cutting-edge applications (TradeLens, 2019).

TradeLens is an open and neutral platform started in 2018 as a joint venture between Maersk and IBM. Maersk owns 51% of the company and IBM holds 49%, being the company responsible for the technological part of TradeLens (Jovanovic et al., 2022). The platform is managed by a company called GTD solution, which although belonging to the same group as Maersk is considered an independent company. To ensure the neutrality of the platform, it is also managed by an advisory board with representation from all the companies belonging to the TradeLens ecosystem (Jovanovic et al., 2022).

TradeLens was chosen because it is one of the blockchain initiatives that has made the most significant impact to resolving global supply chain issues including digitization and shipment monitoring. With almost 300 businesses dispersed over the SC, this platform is a suitable place for Portuguese enterprises to begin experimenting with blockchain-based solutions.

4.5.1 TradeLens Business Model: Ecosystem leverage

The business model defines how the participants of the network obtain economic advantages as well as how the network is financed among all the participants. TradeLens' business value is “to bring global supply chains into a more connected and digitized state for everyone” (Jensen et al., 2019). This platform distinguishes itself from others by allowing its participants to create innovative applications on top of the platform, developing an open application marketplace. Through open APIs, the participants of the TradeLens ecosystem can add innovations that are beneficial to them and that can be used by all members of the community, enabling a faster transformation of the shipping industry (Schreieck et al., 2016). As

interviewee A stated, *"The TradeLens platform aims to give each of its participants more visibility up and down the chain"*.

There are three main apps developed by TradeLens on the marketplace, corresponding to TradeLens' core business and therefore its biggest source of income (Jovanovic et al., 2022). The first is TradeLens Core which is a supply chain management tool that collects and delivers shipping information, through an open API, to the ecosystem participants. This application can give live transportation insights and send alerts, in case of need, in the form of notifications to any device (TradeLens Core, n.d.). The second application is the electronic bill of lading (eBL) which is an electronic version of the traditional BL, mentioned previously (TradeLens eBL, n.d.). The third application is a Bill of Lading Verifier, which is specifically designed for banks and other financial institutions to enable more efficient trade financing procedures (TradeLens eBL, n.d.).

Furthermore, the TradeLens blockchain architecture allows the development and application of smart contracts. As referred by interviewee A, smart contracts add value to this platform insofar as they mitigate the existence of ambiguities in the interpretation of the conditions of a certain contract. TradeLens, with the help of smart contracts, is focused on streamlining the approval processes of certain regulatory documents. According to this interviewee (A), TradeLens rules, methodologies, and procedures translated into smart contracts are Maersk's intellectual property. As such, they are on a closed network and not open source like other applications, which limits their analysis.

Besides these applications, TradeLens with the development of the marketplace was able to engage more companies in the supply chain industry into their ecosystem, leading to its expansion. TradeLens' business model depends on mass acceptance by companies located

along the supply chain. This is because if the majority do not use this platform, the problems of inter-system connectivity will persist.

4.5.2 Organization Governance

The analysis of the TradeLens governance model will be divided into two parts: Technology ecosystem governance and Interoperability governance. The first level will address the architecture of the platform and the data-sharing model between its participants, and the second level will focus on how the current company's systems can be integrated with the blockchain system of TradeLens.

Technology ecosystem governance (Platform architecture)

Blockchain has always been the technology used by TradeLens as it ensures the distribution of power over a shared ledger among multiple parties, where no single entity can have absolute power over the system. TradeLens' blockchain is a new version of an open blockchain made available by the Linux Foundation (Hyperledger). As stated by Interviewee A, the new version developed by IBM aimed to apply all the qualities of a public blockchain to the business world and became known as Hyperledger Fabric.

To decentralize the network, TradeLens allowed ocean carriers to host and manage a blockchain node. These members, usually called "trust anchors", are allowed to make a copy of TradeLens's private permissioned blockchain ledger for their node. These nodes have the responsibility of maintaining the consensus mechanism by validating transactions and hosting data (Jovanovic et al., 2022). They are known to the network by their cryptographic identities. The fact that only trust anchors are allowed to have a copy of the ledger and validate transactions makes the network faster. This happens because validation is done by fewer nodes, i.e., the "truth" must be replicated fewer times, and therefore there will be less interactions between nodes. The figure 3 in appendix, illustrates the TradeLens architecture.

Data sharing model: Ensuring security

In terms of data access, TradeLens by using a permissioned blockchain was able to develop a specific data-sharing model. This model can organize the actors involved in three main layers: shipment, consignment, and equipment (TradeLens, 2020). Shipment incorporates the commercial and financial transactions between the seller and the buyer, including the buyer's and the seller's banks. Consignment is the operational execution of the agreement reached in the shipment layer, including other organizations such as ports and inland transportation providers (Jovanovic et al., 2022). Finally, equipment is just the structure that allows the transportation of the goods that are part of the commercial relationship (e.g., shipping containers). There are many relationships between these three layers, and it's based on them that TradeLens identifies the role of each ecosystem actor, and therefore determines what information each actor can access (TradeLens, 2020).

TradeLens ensures security by using the Hyperledger Fabric "*channel architecture*". A channel is created for each ocean carrier (trust anchor) and the information is only shared with the nodes participating in the same channel, as it's possible to see in figure 4 in the appendix. Meaning that no customer information from ocean carriers will be shared with other ocean carriers who are not involved in a specific transaction. Documents are only stored in one node per channel and based on permissions, the other nodes can have live access to them using a particular connection (Rukanova et al., n.d.). In this way, network participants retain sovereignty over their data, while TradeLens manages the operational integration of these different ecosystem actors through standard protocols (TradeLens, 2020).

4.5.3 Interoperability governance

As seen previously, ensuring compatibility between traditional systems and the distributed blockchain system is a decisive factor for companies to be able to enter the ecosystems

provided by platforms such as TradeLens. There are two main ways to connect with TradeLens, explained below.

The first one is more favorable to larger companies and consists of using open application programming interfaces (API). Through an API companies can connect their current systems (legacy systems) with the TradeLens platform. The main challenge in this type of system integration is the creation of an API gateway. This gateway has the function of translating the format of the requests made by a traditional system so that they fit with the standards of a blockchain system. Members of the ecosystem can also utilize a user interface, instead of integrating their systems with the platform, as can be seen in the figure 5 in appendix. This solution is for the benefit of smaller companies, that do not have well-developed systems or who consider integrating them with TradeLens too expensive. Therefore, the way each company/entity integrates its systems with the TradeLens platform, will depend on the size of the company and/or the amount of data exchanged (Jovanovic et al., 2022).

4.5.4 Practical application: The case of Syngenta

After presenting the business model and the technological architecture of the TradeLens, it is important to visualize a practical example of the application of this platform. The example chosen is about a Swiss agtech company named Syngenta, which regularly needs to import cargo from South Korea to Bangladesh (Sealand, 2022). The company chooses to finance its imports through a letter of credit issued by the Singapore-based HSBC bank.

The process on TradeLens' platform begins when the shipper shares the shipping instructions with the ocean carrier. After receiving the instructions, the ocean carrier needs to create a bill of lading draft that should also be approved by the shipping company. After the approvals, the BL is shared by TradeLens with other participants in the shipping process, such as port authorities and the cargo owner. At this time the BL and other trade documents are also shared

with the importer's bank (HSBC) for authorization, and then shared with the bank in Bangladesh. Finally, after fulfilling all the conditions of the cargo transfer agreement, the BL is shared, on the platform, with the importer allowing him to collect the cargo from the ocean carrier.

The major difference between TradeLens systems and the traditional one is that documents can be shared digitally between participants in the process in a matter of seconds, decreasing the interactions between them as illustrated by figure 6 in the appendix. In the traditional system, to share physical documents between participants, the documents need to be transported by air courier, which delays the whole process. TradeLens through its sophisticated permission model, documents are only shared with the various participants in the process at the appropriate time. Therefore, by using TradeLens, Syngenta has been able to decrease by 10 to 14 days the time needed to process trade documentation (Sealand, 2022).

4.5.5 Limitations: Mass adoption problem

TradeLens has managed to achieve significant adoption by major containers shipping companies - such as Mediterranean shipping company, CMA CGM, and Hapag-Lloyd, and major ports/terminals such as PSA International, APM Terminals (owned by Maersk), DP World and China Merchant Holdings International (Jensen et al., 2019). While the uptake by these companies and ports has been important, the problem is that few custom authorities have accepted this platform for trade reporting. Since full global industry collaboration was not achieved, the platform had to be shut down by Maersk and IBM at the beginning of December 2022. This outcome demonstrated the need for mass adoption of this type of platform so that it does not become useless. Although the business value of TradeLens was based on the continued expansion of its ecosystem, it was not possible to resist the lack of adhesion by the customs authorities around the world.

4.6 Final Discussion

Throughout this chapter, it has been proven that the blockchain can solve some long-standing problems in MSC, and thus streamline the international trading system. More specifically, blockchain, through platforms like TradeLens, has provided solutions for the three flows that characterize the cross-border trade. Regarding the logistic flow, it is possible to highlight the solutions brought by this technology around cargo tracking along the SC. In relation to the documental flow, blockchain contributes to the digitalization of SC, a key aspect to reduce shipping time. Finally, in the monetary flow, it contributes to the simplification of the trade finance process through the creation of digital versions of the L/C.

The analysis performed in this chapter allowed us to realize that although there is little doubt about the usefulness of blockchain for SC, the implementation of this technology in Portugal faces several technological, organizational, and environmental obstacles. Some of these obstacles, such as the scale of Portuguese enterprises, are structural in nature and hence more difficult to overcome in the short term. Other difficulties, such as the complexity of system integration or the traditional mentality of Portuguese enterprises, are projected to be more readily overcome as technology advances and these organizations get more understanding on the subject. Given this, there is still a long way to go in Portugal, and as mentioned by interviewee C, it should begin with education on the blockchain topic and greater participation from large companies in pilot projects to reduce the costs of implementing the technology. Additionally, it is crucial that Portuguese maritime SC firms understand that a blockchain initiative is only successful if participants are willing to share information and work together to achieve a common goal.

5 Conclusion

5.1 Discussion of results

Although the concept of blockchain technologies have been around for a few decades, it has only recently received international recognition as a source that can drive innovation and possibly change the course of modern technology. Throughout this paper, we have examined the use-cases for blockchain, and have concluded that this form of technology can potentially have enormous amounts of impact on numerous industries and sectors. Likewise, the reasons for adoption in each case are similar – providing higher levels of security, transparency, traceability, speed, and much more. However, it's important to note that although the technology does provide benefits, this thesis concludes that organizational leaders do understand that not all companies may be suited for adoption, e.g., companies may perform a cost-benefit analysis to quantify the marginal benefit.

Although the basis of the benefits is similar, the obstacles faced by companies in the different industries have proven to be independent. One significant barrier has emerged from research on the use of blockchain in supply chains and the public sector: the requirement for broad acceptance by most of the organizations involved in these two sectors. The development of a sizable and stable ecosystem, where participating companies rely on the network to store and distribute each other's information, is crucial for the feasibility of a blockchain initiative in these two sectors. According to the findings of this thesis, the key distinction in the wellbeing sector, is that blockchain is utilized to resolve internal organizational issues and therefore does not need to rely on other external parties to guarantee the project's success. Blockchain projects in the wellbeing sector also depend on the development of a robust ecosystem, but this ecosystem is made up of internal business members: the firm's employees. These were the broad barriers that were seen in the many industries that were examined, but it's critical

that businesses consult the different elements outlined in theoretical frameworks (such as TOE or TAM) to identify the specific barriers within critical areas that they could face while implementing blockchain technologies.

According to the case studies examined and the interviews that were performed for this thesis, businesses' knowledge of blockchain technology is the main barrier to its implementation. This challenge may arise as a result that the technology is still relatively new and that it is just recently been applied to the corporate sector through private and permissioned blockchains. To tackle the lack of knowledge about blockchain, large IT firms (e.g., IBM) may positively contribute by educating small and medium-sized companies, since they have greater expertise on creating and implementing blockchain-related initiatives. The government's funding for these training courses can guarantee that all businesses are on the same level of expertise when determining whether to adopt blockchain technology. Therefore, the first step in encouraging the widespread use of blockchain technology is to make sure that all businesses are aware of BC’s potential and how to apply it to their operations.

5.2 Limitations

Numerous limitations were faced throughout the course of this paper. Firstly, this paper utilizes the TOE and TAM framework to evaluate factors that should be considered for technology adoption. These two frameworks provide limited insight into technology adoption, hence other variables need to be considered. Additionally, the sample size of the qualitative findings cannot provide a general overview at a population level and need to be further explored and verified by quantitative analysis. Other limitations faced include the limited accessibility to blockchain to engage in the qualitative study due to the novelty of the topic, along with the limited time constraint.

5.3 Implications and Future Research

In light of the limitations identified throughout the thesis, the investigation of the use of blockchain and smart contracts in the different scenarios mentioned should continue in the context of future research, addressing the topics described below.

The analyses developed within the scope of blockchain technology adoption in different scenarios should be seen only as the beginning of a more advanced analysis to be conducted in the future. In this advanced analysis, other frameworks besides TOE and TAM should be introduced to overcome the aforementioned limitations. This study should include as many respondents as possible in two universes: private companies in the area of smart contracts, wellbeing, supply chain and public sector companies; and additionally have the participation of the governments of the countries where the study is carried out. By gathering several participants from these two universes, this study will be able to achieve a closer view of the reality of what the adoption of blockchain will be in the future.

This thesis examined several scenarios of blockchain deployment in private and public enterprises, focusing on cases when a corporation utilizes just one blockchain. Companies may soon be required to engage in more than one blockchain to tackle different concerns. In the near future, as an example, a corporation may be participating in three separate blockchains: one to promote employee wellbeing, another to use smart contracts as labor contracts, and still, another to assure the efficiency of the logistical process. The findings of this thesis imply that such as scenario is very likely to happen soon. Having stated that, this thesis wants to challenge the blockchain development community to provide a solution that allows a company's blockchains to be interconnected. Thus, establishing a “network of networks” will enable enterprises to unlock the full potential of blockchain technology.

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7 Appendix

7.1 Abbreviations

API	Application Programming Interface
BC	Blockchain (technology)
BL	Bill of Lading
EU	European Union
L/C	Letter of Credit
MSC	Maritime Supply Chain
NFT	Non-Fungible Token
OECD	Organization for Economic Cooperation and Development
SC	Supply Chain
TAM	Technology Acceptance Model
TOE	Technology-Organization-Environment framework

7.2 Overview of in-text Tables & Figures

7.3 Tables and Figures

Table 1: Most relevant trade documents

Document	**Description**
Bill of Lading (BL)	A legal document issued by a carrier to a shipper that details the type, quantity, and destination of the goods being carried
Letter of Credit (L/C)	A letter from a bank guaranteeing that a buyer's payment to a seller will be received on time and for the correct amount
Certificate of Origin	A document issued by the authorities in the country of origin verifying the shipment's origin and content
Packing List	A detailed statement of the contents of a package, which is used by the buyer to verify the contents
Commercial Invoice	Document required by customs authorities to determine the value of the imported goods for the assessment of duties and taxes
Export Certificate	A government document allowing the licensee to export a certain number of products to a certain nation

Figure 1: Document flow across the supply chain in the current/traditional system (Jensen et al., 2019)

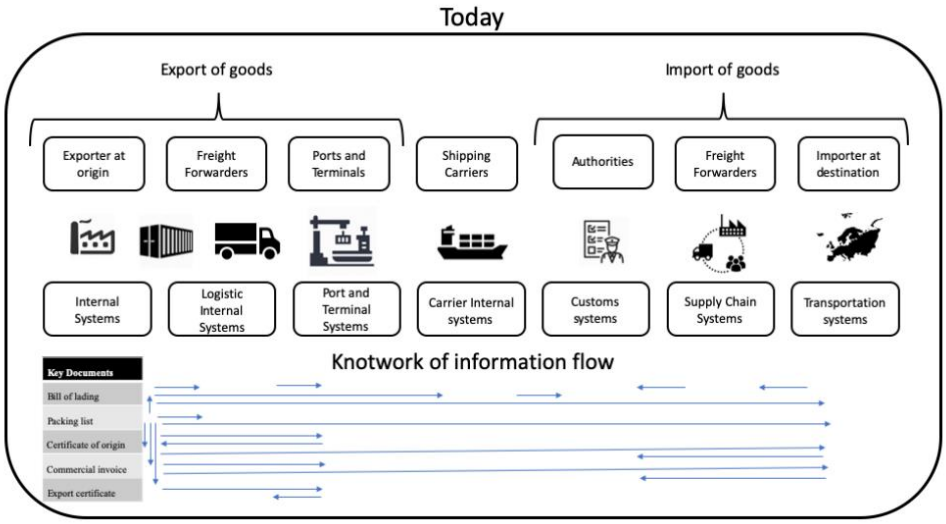


Figure 2: Letter of the credit payment process in international trade (Chang et al., 2019)

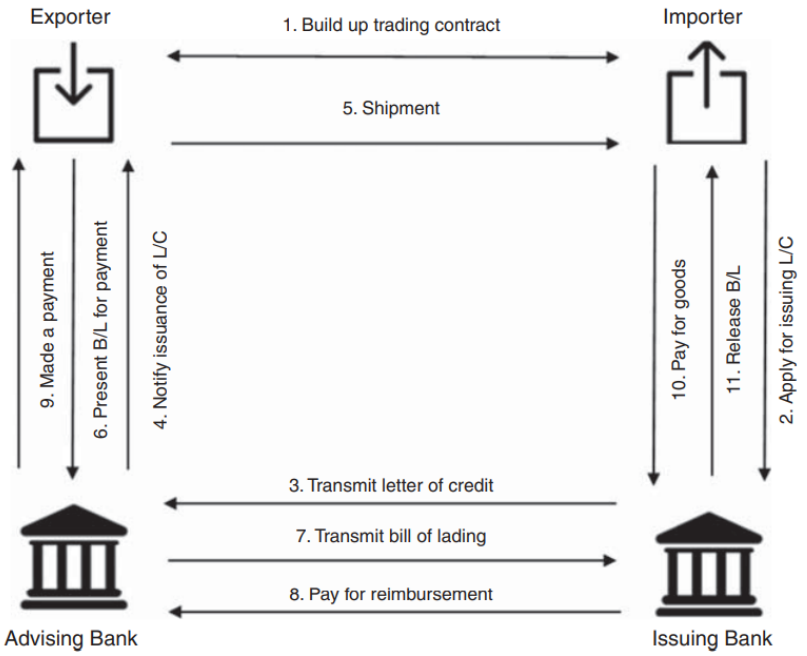


Figure 3: TradeLens architecture (Jensen et al., 2019)

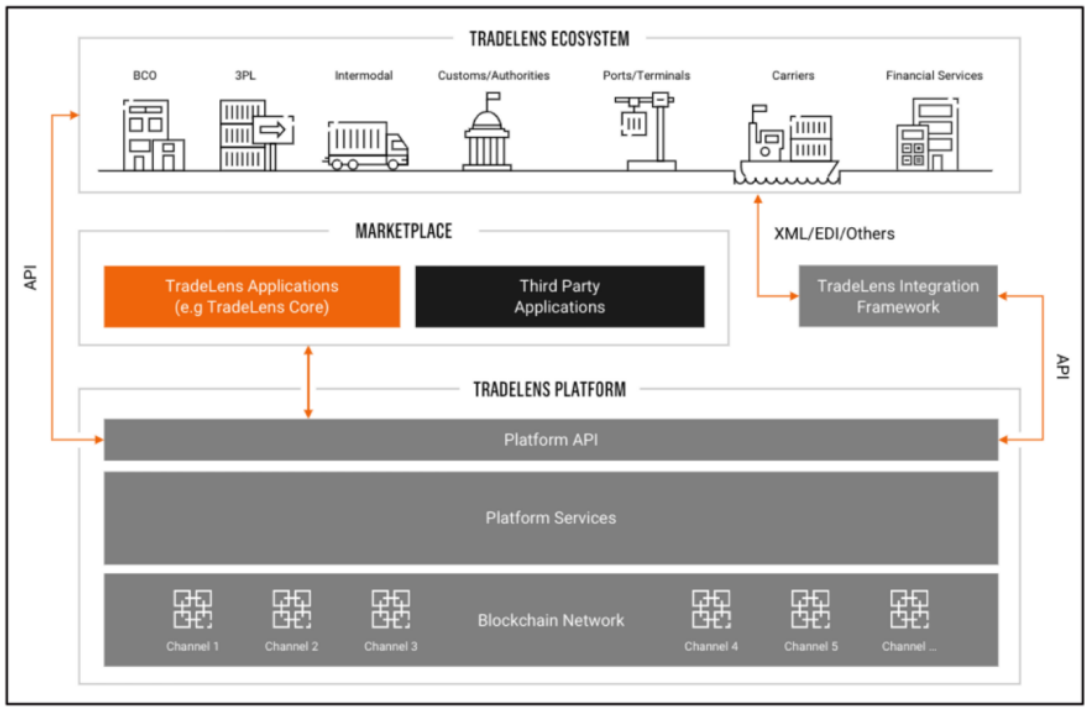


Figure 4: Data sharing model (Jensen et al., 2019)

Figure 5: The shipment manager user interface (TradeLens website)

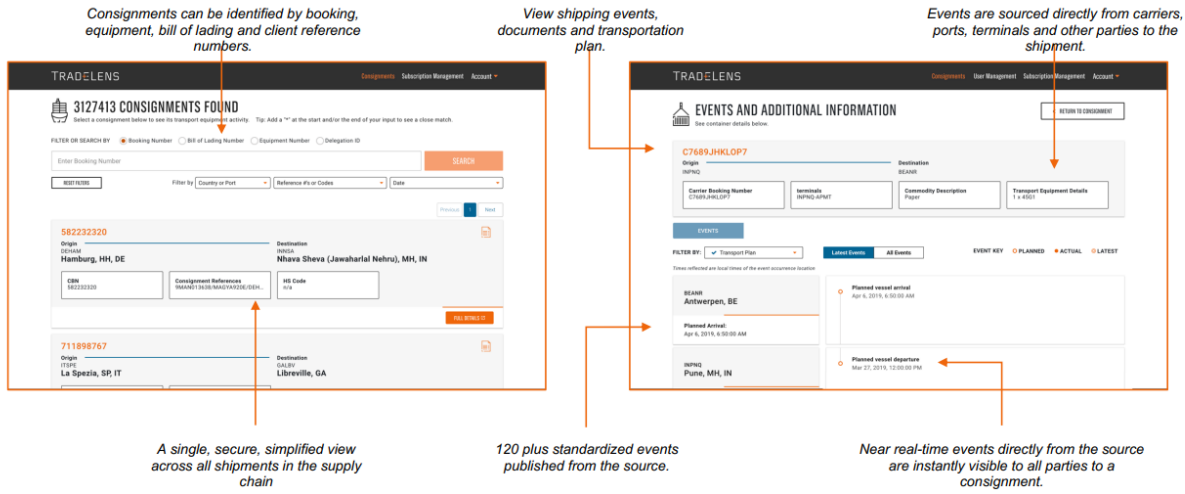
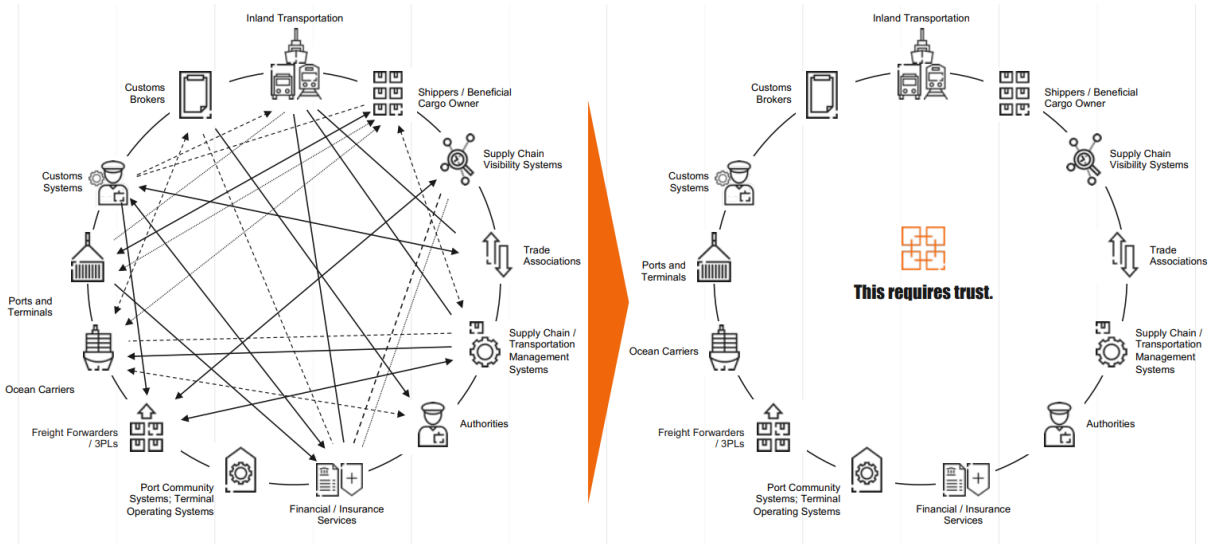


Figure 6: Traditional system/model vs Blockchain network system (TradeLens website)



7.4 Interview Guide

Introduction

- Brief introduction
- Thank for participation in interview
- Ask for consent to record and transcribe parts of the interview for analysis
- Inform interviewee about confidentiality
- Explain context of interview and the scope of the specific part to interviewee
    - Master thesis on blockchain adoption across different sectors and the factors that influence this
    - Individual part: blockchain adoption in the public sector

Start recording of interview

Common Questions & Background	• Who are you and what is your current role(s)? • Can you tell me about the experience you have with blockchain in general and its implementation within the public sector? • What are the most relevant factors when determining whether or not to implement blockchain technologies? • What are the challenges to implement blockchain?
Technical	• What aspects/qualities of blockchain are especially relevant to your industry? • How do you evaluate the complexity of implementation? o *Compatibility with existing systems?* • What are the most relevant factors when determining whether or not to implement blockchain technologies?

Organizational	• How do organizational aspects influence the adoption?
	  o *How does the management influence this?*
	  o *How does company culture (mission, vision, ..) influence this?*

	○ *How does firm size impact this?* ○ *How does technological expertise?*
Environmental	• What are the use-cases of blockchain in your industry? • Are your (direct or indirect) competitors adopting? • General impact on industry function? • Limitations? • Regulation?
Perceived usefulness / Perceived ease of use	• What do you estimate to be the major benefits to implementing blockchain? ○ *(efficiency, cost, time, service, etc,)* • How do entities that adopt a blockchain [within company/sector] evaluate the perceived ease of use?

Stop recording of interview

Closing

- Clarification of outstanding questions
- Thank you for participation in the interview

7.5 Internal considerations for interviews

- This interview guide only serves as a general structure to the interview and is not to be understood as a strict step-by-step guide. The intent is to provide a general framework to extract expert knowledge and insights from the interviewee.
- The general assumption is that the interviewees chosen for the interview have expert knowledge that goes beyond the knowledge of the research team. Therefore, the interviewer should be flexible and adapt to the narrative of the interviewee.
- The interviewer is responsible to adapt the questions in the guide with common sense to the individual perspective of the expert interviewed and the sector that is applicable to gain insight into the research scope (e.g., consultants are asked about how their clients (that are relevant to scope) are perceiving and evaluating the above factors rather than asking them about their own organization).
- The sub-bullet points in (*cursive*) only serve as an indicator for the interviewer to make sure the most relevant points are mentioned and are not shared with the interviewee to avoid suggestive questions.
- Therefore, this guide is only a tool to the research team and not to be shared with prospective and actual experts that are interviewed for this thesis.
- Interview recordings are saved in the shared folder for all members of the research group to access, with due care of all applicable confidentiality standards
- Default interview language is English if possible. In case interviewee is not able to perform interview in English or it is expected that interviewee's ability to share expert knowledge to full extent is impeded, interviews will be conducted in language the interviewee is most comfortable with. In this case the interview will be translated and transcribed by original interviewee to ensure content is captured accurately and reflects insights shared by expert.

7.6 Overview of interview participants

Code	Chapter	Role description	Organization type	Sector	Blockchain Relevant experience
A	Maritime supply chains	Associate Partner	Large Company	Technology	6 years
B	Maritime supply chains	Director	Medium-sized company	Maritime logistics	N/A
C	Maritime supply chains	Director	Large Company	Logistics	2 years

7.7 Transcription rules

Content-semantic transcription according to Dresing and Pehl:

1. Transcription is verbatim, i.e., not phonetic or summary.
2. Word slurs are approximated to written Englisch. The sentence form is retained, even if it contains syntactic errors.
3. Dialects are translated into as accurately as possible. If no clear translation is possible, the dialect is retained.
4. Colloquial particles are transcribed.
5. Stuttering is smoothed or omitted, broken words are ignored. Word doublings are recorded only when used as a stylistic device for emphasis: "This is very, very important to me."
6. Half-sentences that lack completion are marked with the break-off character "/".
7. Punctuation is smoothed out in favor of readability, that is, a period rather than a comma is used for brief lowering of the voice or ambiguous emphasis. Units of meaning should be retained.
8. Receptive signals such as "hm, aha, yes, exactly" that do not interrupt the other person's flow of speech are not transcribed. They are transcribed when they are mentioned as a direct response to a question.
9. Pauses of about 3 seconds or more are marked by (...).
10. Especially emphasized words or utterances are marked by VERSALIEN.

11. Each speaker's contribution receives its own paragraphs. There is a free, empty line between the speakers. Short interjections are also transcribed in a separate paragraph. Time marks are inserted at least at the end of a paragraph.

12. Emotional nonverbal expressions of the interviewee and the interviewer that support or clarify the statement (such as laughing or sighing) are noted in parentheses when used.

13. Unintelligible words are marked with "(unv.)". Longer unintelligible passages are marked with the reason if possible: "(unv., microphone rushes)". If a wording is suspected, the passage is put in brackets with a question mark, e.g. "(axe?)". Incomprehensible passages are marked with a time mark if no other time mark is set within one minute.

14. The interviewing person is marked by an "I:", the interviewee by a "B:". In case of several interview partners (e.g. group discussion), the abbreviation "B" is assigned a corresponding identification number or name ("B1:", "Peter:").

15. The transcript is saved as a Rich Text Format (RTF) file. The naming of the file is done according to the media file name (without extension wav, mp3), for example: Interview_04022011.rtf or Interview_schmitt.rtf.

Source: Dresing, T., Pehl, T., Interviews, 2018, p. 19.

Adaptations:

- The applications of the 11th, 14th and 15th rule are omitted, which have no relevance in the context of the present work.

- For the purpose of clarity, the interviewees are abbreviated by the letters A to D in the context of the transcripts

7.8 Interview analysis

7.8.1 Interviewee Code A

Related to WP Project chapter: Blockchain application to the international maritime supply chains and cross-border trade

Interview code: D

Interviewee: Associate Partner of IBM Consulting and director of the Hybrid Cloud Services department, with 6 years of experience in the blockchain sector, developing projects in the transformation of the banking industry in Portugal and Europe.

Interviewer: Francisco Ferraz

Place of interview: Online via Webex

Time and date: 4th of November from 18:00 until 19:45 (duration: 1h45 minutes)

Transcription: Francisco Ferraz

Interview language (reason): Portuguese (since both participants are Portuguese, it was the language agreed upon for the interview)

Translated transcript (relevant selected quotes)

Factor/Category	**Interview quote**	**Paraphrase**
Background	"In 2016 when I moved to IBM, I became part of the global group of banking CTOs and was given a mission to try to develop the solutions and sell the projects that involved blockchain in banking."	Experience as Associate Partner at IBM Consulting

Blockchain experience	"That's where my connection to blockchain started, in February 2016. With my participation first in a standards organization for banking which is Bayen, where the topic started to be touted as being a technical area that could possibly expand use cases in banking."	First experiences in the Blockchain area
Technological	" The systems that exist in companies, called traditional, are by nature not distributed, they are centralized systems. What makes communication between the two possible requires understanding the different paradigms. For this, I have to create a gateway connecting the two worlds, which are studied, but which are complex if the company doesn't assume that to work in blockchain it has to learn to work with distributed systems".	Integration between traditional systems and distributed systems (Blockchain)
Organizational	"In Portugal, we have many very small companies and few very large companies, we don't have that "sweet spot" of there being many medium-sized companies there where that makes all the sense between them decide look: we are not big enough, so for us costs are a very important thing, let's find a way to come together to gain efficiencies"	Medium-sized companies has the ones with higher advantages in investing in Blockchain
Organizational	"A blockchain project costs more, not because the technology is expensive, but because of the way of working in a team, of having so many participants, of having to work at the speed of the slowest, of having to agree among everyone what to do, it makes these projects take longer. We don't have a homogeneous enough market to guarantee that these ecosystems are born and grow easily.	Costs of blockchain projects and heterogeneity of Portuguese companies as an obstacle to blockchain adoption

Organizational	"I think [that the adoption of blockchain] is paradigmatic of the structure of companies in Portugal, not so much that we are more technologically backward, because we are not (...) We have a lot of training in distributed systems in Portugal, we have good technicians coming out of universities who understand distributed systems and who can easily enter the blockchain world.	The size of Portuguese companies as an obstacle to blockchain adoption
Environmental	"The bastions of innovation are countries that for various reasons, either because they had too much fraud or because they were not very efficient, took a very big technological leap, like Estonia and Dubai, which decided that the blockchain would be used. In other countries like Portugal things take longer since Portugal as a member of the EU has to reach a consensus with the other countries on the subject.	Portugal delays in regulation in relation to other countries.
Environmental	"There are various political and other movements, also market movements, that make the laws move faster or slower. It depends a lot on political will, a lot."	Factors that influence the speed of creating legislation on new technologies
Environmental	"The regulations have to be adapted to meet the specifics of the application in practice, so it's taking some time, as it has over the years with other technologies like digital signatures."	Portugal normal delays in crate laws regarding new technologies
Environmental	"Portugal is behind [in regulation], it was behind for many years (...) A paradigmatic case was the ability to onboard a customer by video call, for example in a bank (...) The simple signing of a document had to be witnessed by a bank employee (...) When did the effective change in the law occur? When foreign banks with subsidiaries in Portugal launched the service because they obeyed more advanced laws".	An example of delays in the creation of laws

TradeLens	"In the case of TradeLens, they used Hyperledger Fabric"	TradeLens blockchain
TradeLens	"The smart contracts you don't find much information available because in the case of TradeLens, the TradeLens business rules and the methodologies, the procedures that are basically translated into those smart contracts are Maersk's intellectual property. And so it's a closed network in that sense."	Smart contracts as intellectual property of Maersk
TradeLens	"A smart contract translates faithfully what is everyone's interpretation of the terms and conditions of the legal contract you are trying to automate on the blockchain (...) A smart contract is only enforceable when all parties decide that they all have the same understanding".	Features of smart contracts

Original transcript

Factor/Category	**Original quote**
Background	“Em 2016 quando passei para a IBM, passei a fazer parte do grupo global de CTOs de banca e foi me dada uma missão de tentar desenvolver as soluções e vender os projetos que envolvessem blockchain na banca”
Blockchain experience	“Começou aí a minha ligação ao blockchain, em fevereiro de 2016. Com a minha participação primeiro numa organização de standards para a banca que é o Bayen, onde o tema começou a ser tocado como sendo uma área técnica que possivelmente pudesse expandir casos de usos na banca”
TradeLens	"No caso da TradeLens eles usaram Hyperledger Fabric”
TradeLens	"O smart contracts não encontras muita informação disponível porque no caso da TradeLens, as regras do negócio da TradeLens e as metodologias, os procedimentos que no fundo estão traduzidos nesses smart contracts são propriedade intelectual da Maersk. E, portanto, é uma rede fechada nesse sentido”
TradeLens	"Um smart contract traduz fielmente aquilo que é a interpretação de todos dos termos e condições do contrato legal q se esta a tentar

	automatizar no blockchain (…) Um smart contract so passa a ser executado quando todas as partes decidirem que todos têm o mesmo entendimento”
Organizational	"Um projeto de blockchain sai mais caro, não porque a tecnologia é cara, mas pela forma de trabalhar em equipa, de ter tantos participantes, de ter de trabalhar a velocidade do mais lento, ter de acordar entre todos o que fazer, faz com que estes projetos demorem mais tempo. Nós não temos um mercado suficientemente homogéneo para garantir que estes ecossistemas nascem e crescem de forma fácil”
Organizational	"Em Portugal, temos muitas empresas muito pequenas e poucas empresas muito grandes, não temos aquele “sweet spot” de haver ali muitas empresas médias em que essa faz todo o sentido entre elas decidir olha: não somos suficientemente grandes, portanto para nós os custos são uma coisa muito importante, vamos lá encontrar forma de nos juntarmos para ganhar eficiências “
Organizational	" Eu acho [que a adoção da blockchain] é paradigmático da estrutura de empresas em Portugal, não tanto de estarmos mais atrasados tecnologicamente, porque não estamos (..) Temos muita formação em sistemas distribuídos em Portugal, temos bons técnicos a sair das universidades que percebem de sistemas distribuídos e que facilmente podem entrar no mundo blockchain”
Technological	" Os sistemas que existem nas empresas, chamados de tradicionais, não são por natureza distribuídos, são sistemas centralizados. O que faz com que a comunicação entre ambos seja possível obriga a compreender os diferentes paradigmas. Para isto tenho de criar um gateway de ligação entre os dois mundos, que estão estudados, mas que são complexos se a empresa não assumir que para trabalhar em blockchain tem de aprender a trabalhar com os sistemas distribuídos”
Environmental	"A regulamentação tem de ser adaptada para conhecer as especificidades da aplicação na prática, portanto está a demorar algum tempo, como tem demorado ao longos dos anos com outras tecnologias como as assinaturas digitais”
Environmental	"O Portugal está atrasado [na regulamentação], esteve atrasado durantes muitos anos (…) Um caso paradigmático foi a capacidade de fazer um onboarding de um cliente por videochamada por exemplo num banco (…) A simples assinatura de um documento tinha de ser presenciada por um trabalhador de um banco (…) Quando é que ocorreu a efetiva alteração da lei? Quando os bancos estrangeiros com subsidiarias em Portugal lançaram o serviço, porque eles obedeciam a leis mais avançadas”

Environmental	"Há vários movimentos políticos e não só, também de mercado, que fazem com que as leias avancem mais depressa ou menos depressa. Depende muito da vontade política, muito mesmo"
Environmental	"Os bastiões da inovação são países que por diversas razões, ou porque tinham demasiada fraude ou porque eram pouco eficientes deram um salto tecnológico muito grande, caso da Estónia e do Dubai que decidiram que o blockchain iria ser usado. Noutros países como em Portugal as coisas demoram mais tempo, dado que Portugal como membro da EU tem de chegar a consenso com os outros países sobre o assunto"

7.8.2 Interviewee Code B

Related to WP Project chapter: Blockchain application to the international maritime supply chains and cross-border trade

Interview code: E

Interviewee: Seafreight and Bulk Director at Garland Transport Solutions

Interviewer: Francisco Ferraz

Place of interview: Online via Microsoft Teams

Time and date: 5th of December from 11:00 until 11:45 (duration: 45 minutes)

Transcription: Francisco Ferraz

Interview language (reason): Portuguese (since both participants are Portuguese, it was the language agreed upon for the interview)

Translated transcript (relevant selected quotes)

Factor/Category	**Interview quote**	**Paraphrase**

Background	" I am a maritime director at Garland, I have been with the group for 42 years. As director, I have been here since 2003. I started in 1980 doing accounting for ships that came to Leixões, conventional ships there were still few container ships (...) In the maritime department I started by doing imports, then exports, and the commercial part. However, I went up and was responsible for a department in the North and, therefore, afterward in 2003 I became a national director at the maritime level.	Experience in the maritime transportation sector
Technological	"We [Portuguese shipping companies] are evolving and we have to continue to evolve on an IT and technological level there is no doubt if we don't lose the development ride."	Current state of Portuguese maritime supply chain companies in terms of technology
Organizational/ Technological	"Garland has clients from the garage, a client that produces very little, to clients with large factories. It's logical that the garage customer fills everything out by hand, but it's very difficult to change that. (...) Digitization is a matter of mentality, of starting to demand more digital documentation and so you'll get there. Changing the mentality needs its time, as does the technological part."	Mentality about technology adoption
Organizational	"We are often resistant to change, when I started working to get anything done [in terms of technology implementation] it took a terrible struggle"	
Environmental	"The lack of trust between shipping companies and banks is still great which makes it difficult to scan documents like the letter of credit. Unfortunately, this mistrust has a purpose, I have received original BLs that are completely fake."	Trust issues in supply chain companies
Environmental/ Technological	Most of the documental part is already digitalized, both at BL and euro1 level. In relation to other documents such as the certificate of origin, there is no	The regulation about digital documents

	homogeneous national response, some customs in Portugal accept the scanned document and others do not (...) In relation to the letter of credit, in Portugal, there is a lot of resistance from banking entities in terms of this part of the document being digital.	

Original transcript

Factor/Category	**Original quote**
Background	" Sou diretor marítimo na Garland, estou no grupo há 42 anos. Como diretor estou cá desde 2003. Comecei em 1980 a fazer contabilidade de navios que vinham a leixões, navios convencionais ainda havia pouco navios de contentores (…) No departamento marítimo comecei por fazer importação, depois exportação e também a parte comercial. No entanto fui subido e fui responsável por um departamento no Norte e, portanto, depois em 2003 passei a Diretor nacional a nível marítimo"
Technological	"Estamos [empresas portuguesas do transporte marítimo] a evoluir e temos que continuar a evoluir a nível informático e tecnológico não há dúvida se não perdemos a boleia do desenvolvimento."
Organizational	"A Garland tem clientes desde garagem, um cliente que produz muito pouca coisa, até clientes com grandes fábricas. É lógico que o cliente de garagem preenche tudo à mão, é muito difícil mudar isso. (…) A digitalização é uma questão de mentalidade, de começarem a exigir mais documentação digital e assim vai-se chegar lá. Mudar a mentalidade precisa do seu tempo, assim como a parte tecnológica,"
Organizational	"Muitas vezes somos resistentes à mudança, quando comecei a trabalhar para se fazer qualquer coisa [em termos de implementação de tecnologia] era preciso uma luta terrível"
Environmental	"A falta de confiança entre as empresas de shipping e os bancos ainda é grande o que dificulta a digitalização de

	documentos como a carta de crédito. Infelizmente esta desconfiança tem um propósito, eu já recebi BLs originais que são completamente falsos.”
Environmental	Grande da parte da parte documental já está digitalizada, tanto a nível de BL como euro1. Em relação a outros documentos como o certificado de origem não há uma resposta a nível nacional homogénea, algumas alfandegas em Portugal aceitam o documento digitalizado e outras não o aceitam (…) Em relação à carta de crédito, em Portugal existe muita resistência por parte de entidades bancarias a nível dessa parte documental ser digital”

7.8.3 Interviewee Code C

Related to WP Project chapter: Blockchain application to the international maritime supply chains and cross-border trade

Interview code: F

Interviewee: Logistics director at Tempus International and Blockchain enthusiast

Interviewer: Francisco Ferraz

Place of interview: Phone call

Time and date: 8th of December from 11:00 until 11:50 (duration: 50 minutes)

Transcription: Francisco Ferraz

Interview language (reason): Portuguese (since both participants are Portuguese, it was the language agreed upon for the interview)

Factor/Category	**Interview quote**	**Paraphrase**
Background	"I am the director of logistics for a large retail company called Tempus International, which has the Boutique dos Relógios brand. Previously I spent 11 years at Portugal Telecom in reverse logistics, transport management, and facilities management. Recently, six years ago, I came to the company where I am now, being responsible for the import of products/materials, storage, and distribution to retailers.	Experience in Logistics industry
Blockchain experience	"Blockchain is my curiosity, blockchain has to do with technology, and I as a person who likes technology have been interested in the topic for some time"	Knowledge about blockchain
Technological	"The best friend of much of the Portuguese air and ocean carrier partners is still Microsoft excel and email. There	Current technology used

	is already much more access to portals, software, and data integration, but there is still a lot to do in the digitization of maritime supply chains."	in maritime supply chains
Technological	"The technology is emerging, but then it needs sponsors, business companies that put this technology in the spotlight and put it on a level that everyone wants to use, to start developing it and for its cost to decrease (...) The big companies are the only ones with this capacity to act as sponsors of the technology. Small companies are not able to give visibility to technology".	Large companies as sponsors of blockchain
Technological	"A small Portuguese company alone cannot decide to make a blockchain. Blockchain is a data sharing technology, companies must be willing to cede information and join forces to gain advantages from the technology"	Conditions for companies to adopt blockchain
Organizational	"Microenterprise defines the Portuguese business chain"	Portuguese business environment
Organizational	"The Portuguese business structure is a micro-company dominated structure, currently there is no know-how in the heads of these directors and these management partners in the vast majority, about what blockchain is and what you need to do to have blockchain. A lot of people think this is just a computer or a server, it's much more exoteric than that."	Lack of blockchain knowledge in Portuguese companies
Organizational	"The first step in ensuring the adoption of this technology is education on the subject. First, you have to demystify what blockchain is, in a simple way companies have to be trained and informed about blockchain. This training must have support from governments, from the European Union. The training should start by explaining in a simple way what blockchain is,	Education needed in Portugal about blockchain technology

	second step try to show companies that they have more in the gain of sharing than in the secrecy of information. Only then, when companies begin to realize that this is the way forward, will it be possible to trigger common knowledge and foster interest."	
Organizational	"When we enter the microenterprise world, we enter the world of secrecy, that is, that thought that if I share what I have I will lose my business. This is the spirit of a Portuguese company. Blockchain says the opposite: tell me everything you have so that we can all be more efficient. I think this is where the barrier is - it's in the will to share, and if you don't overcome this the technology will have an evolutionary stopper here."	The mentality of a small Portuguese company

Original transcript

Factor/Category	**Original quote**
Background	"Sou diretor de logística de uma grande empresa de retalho que se chama Tempus Internacional, que tem a marca da Boutique dos Relógios. Anteriormente estive 11 anos na Portugal Telecom na área da logística inversa, gestão de transportes e gestão de facilities. Recentemente, há seis anos para cá, vim para a empresa onde estou atualmente, tendo à minha responsabilidade a importação de produtos/materiais, armazenamento, distribuição para o retalho."
Blockchain experience	"A Blockchain é curiosidade minha, a blockchain tem a ver com tecnologia, e eu como uma pessoa que gosta de tecnologia interesso-me pelo tema desde há a algum tempo"
Technological	"O melhor amigo de grande parte dos parceiros dos transportadores aéreos e marítimo portugueses continua a ser o Microsoft Excel e o email. Já existe muito mais acesso a portais, softwares, integração de dados, mas ainda há muita coisa para fazer na digitalização das cadeias de abastecimento marítimas."

Technological	“A tecnologia vai surgindo, mas depois precisa de sponsors, empresas de negócios que ponham essa tecnologia na ribalta e que a coloque num patamar que toda a gente a quer usar, para se começar a desenvolver e para o seu custo de utilização diminuir (…) As empresas grandes são as únicas com essa capacidade de atuar como sponsors da tecnologia. As empresas pequenas não conseguem dar visibilidade à tecnologia”
Technological	“Uma empresa pequena portuguesa sozinha não pode decidir fazer uma blockchain. Blockchain é uma tecnologia de partilha de dados, as empresas têm de estar dispostas a ceder informações e unir esforços para obterem vantagens com a tecnologia”
Organizational	"A microempresa define a cadeia empresarial portuguesa”
Organizational	“A estrutura empresarial portuguesa é uma estrutura dominada por microempresas, atualmente não existe know-how na cabeça destes administradores e destes parceiros de administração na grande maioria, sobre o que é o blockchain e sobre o que é preciso fazer para ter blockchain. Muita gente pensa que isto é apenas um computador ou um servidor, é muito mais exotérico do que isso.”
Organizational	“O primeiro passo para garantir a adoção desta tecnologia é a educação sobre o assunto. Primeiro tem de se desmistificar o que é a blockchain, de uma forma simples as empresas têm que ser formadas e informadas sobre blockchain. Esta formação deve ter apoio dos governos, da União europeia. A formação deve começar por explicar de uma forma simples o que é a blockchain, segundo passo tentar mostrar às empresas que têm mais no ganho da partilha do que no segredo da informação. Só aí, quando as empresas começarem a perceber que é o caminho, é que vai ser possível despoletar o conhecimento comum e a fomentar interesse.”
Organizational	"Quando entramos na microempresa, entramos no mundo do segredo, ou seja, aquele pensamento de se eu partilhar aquilo que tenho vou perder o meu negócio. Este é o espírito de uma empresa portuguesa. A blockchain diz o contrário: diz-me tudo o que tens de modo a sermos todos mais eficazes. Eu acho que é aqui que está a barreira - é na vontade de partilhar, e enquanto não se vencer isto a tecnologia terá aqui um stopper de evolução”
Environmental	"Se há coisas que nós vamos sendo surpreendidos a alteração de compromissos, são definidos compromissos que muitas

	vezes são alterados e muitas vezes o fornecedor é surpreendido e o comprador também é surpreendido (…) A falta de confiança entre as empresas da cadeia de abastecimento é muitas vezes defraudada por falta de conhecimento, por nomeadamente, os players da cadeia de valor não estarem dispostos a pôr em cima da mesa as suas vulnerabilidades"