

An explorative study on blockchain technology in application to port logistics

Master Thesis - Management of Technology 2017

Specialization: Supply Chain Management

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An explorative study on blockchain technology in application to port logistics

By

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in partial fulfilment of the requirements for the degree of

Master of Science

in Management of Technology

at the Delft University of Technology,

to be defended publicly on Monday August 21, 2017 at 16:00 PM.

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Acknowledgements

The commitment on this thesis project spans over the course of six months, during which much was learnt. It was a meaningful journey, both in terms of conducting academic research and gaining personal and practical experience. This research could not have been done without the outstanding contribution of many professional people, who did not hesitate to share their knowledge and understanding on the topic with me.

First and foremost, I would like to offer my gratitude to my supervisors, Dr. Yousef Maknoon, Prof. Marijn Janssen, and Prof. Lori Tavasszy; for their guidance, patience and encouragement. I was given much appreciated liberty in pursuing my ideas and follow my own path. This was combined with regular and constructive feedback that helped me to keep the right track all along the journey. Moreover, their contribution was essential to ensure academic rigor and scientific validity.

I sincerely thanks Dirk Baajen and Dennis Dortland for their dedication and time spent in guiding me. Their experience and expertise had a great impact on the way I addressed and conducted my research. Their enthusiasm and commitment was inspiring throughout the research journey.

Working on the thesis has been a long and at times difficult process. Understanding the real value of such an innovative technology is a process that not only requires commitment but also persistence. Therefore, I would like to thank who gave me the privilege of conducting an interview with them, and who organized and participated in the Smartport white/paper on blockchain and port logistics.

At a personal level, I am very grateful to my family for their continuous support and understanding not only throughout this journey, but throughout many others. In particular, I would like to thank my parents for the outstanding example they gave me during the hard time they went through in the last few years. Last, but not least, I am grateful to all my friends here and abroad for their continuous support, genuine interest and many good talks. The support of each of them was vital throughout my education as well as in accomplishing this MSc master thesis.

I wish you to enjoy reading this thesis as much as I enjoyed writing it.

Mattia Francisconi

Executive summary

Since the initial stages of its development, blockchain quickly spread in different industries other than the financial sector. Supply chain and logistics, in particular, are considered as fertile ground for a blockchain implementation due to the several parties involved in the logistic processes and the lack of trust that usually characterize the industry. Eager to maintain its market position as largest port in Europe, the port of Rotterdam lately started to inspect the new opportunities brought by the technology. Despite the several private projects and start-ups that are blossoming in the market, there is still large uncertainty on the implementations and benefits of blockchain solutions for the industry. Moreover, the academic literature on the topic is still scarce. Therefore, this research aims to categorize the current market applications into four business cases based on the functionality they provide. These different uses of blockchain are subsequently analyzed under six different points of view in order to evaluate the expected benefit that the major stakeholder expect to gain from the technology implementation. Finally, the impact of these business cases is tested on the business model components of the current port information system, Portbase, to identify the disruptive power of the technology.

This research project started from the interest of Smartport (intermediary organization with the aim to align demand and supply for the port to participate in research) to evaluate the potential impact of blockchain to port logistics. The entrance of this new technology in the market not only raised Smartport's interest, but it awed the entire port ecosystem for its promises of complete disintermediation and enhanced process visibility. Some of the largest players in the market have already signed partnerships with IT vendors (IBM-Maersk collaboration) to develop a blockchain solutions and exploit the first mover advantage. The SMEs, on the contrary, rely on the role of Smartport to develop a blockchain solution with whom the entire ecosystem would benefit. Similarly, the port of Rotterdam aims to keep its role as the largest port in Europe in the ever-growing competition on the Hamburg-Le Havre range, where ports such as Hamburg and Antwerp are growing in importance and size.

This research project has Portbase as unit of analysis. The company's perspective enables a detailed and un-biased understanding of the port process information flow. This is due to the neutral position of Portbase in commercial activities and the broad spectrum of the company's activities in the port. Moreover, it enables the researcher to inspect the extent to which the current port information system is affected by the technology implementation. This double perspective on the issue corresponds to a dual objective of the research project. On the one hand, this research aims to evaluate the impact of blockchain to port logistics; on the other hand, it aims to provide recommendation to Portbase on how to adapt its business model to a blockchain implementation.

The analysis started with an extensive description of the import carrier process, which was chosen as the research case study. The reasons behind this choice lay on the several stakeholders and the large amount of information transactions that characterised this particular process. By analysing the current physical, financial and information flows, it was possible to identify the main sources of process delays and bottlenecks. Three are the main causes unveiled by the study: container reshuffling at the terminal, customs and commercial clearance, and hinterland transportation planning. All the three process steps require an increase in information sharing, as well as an enhanced information accuracy and rapidity.

To identify the impact of the technology on port logistics, some process KPIs were defined as an evaluation framework. In particular, the KPIs were selected to appraise the impact of some blockchain use-cases to the three flows of the port process. The blockchain business cases were derived by analysing the current blockchain market applications in the field of supply chain and logistics. By listing and analysing the several applications, the main functionalities were derived. This process resulted in the creation of four business cases of implementation, which are categorized based on the distinct use of the technology they want to make. The first business case aims to use the technology to store and transact cargo documentation; the second one focuses on process information; the third one aims to improve trade finance practices; and the fourth one aims to automatize the operations using internet of things and smart contracts. This business cases analysis consisted in a round of interviews to the main port process stakeholders to evaluate the potential benefits brought by each business case.

The respondents agreed on identifying the first business case as a potential solution for customs clearance, since it ensures accurate and consistent information on cargo documentation all over the chain. Second, the interviewees unanimously agreed on the importance of process visibility on the total process performance. The business case has the potential to increase the coordination among the stakeholders as a result of more process information sharing. This business case would speed up the hinterland transportation planning as well as the customs clearance. Third, a blockchain solution for trade finance is expected to reduce the time required for commercial clearance. Enabling parties outside of the physical process (banks, insurance) to have visibility over the process is beneficial to solve bottlenecks due to sequential activities such as the commercial clearance. Finally, the respondents expect the fourth business case to have a significant impact on port logistics, but they identified it as a long-term scenario compared to the previous three.

The impact of the blockchain business cases on the Portbase's business model was evaluated making use of the business model stress-testing tool. This analysis started with a description of the company's business model based on the CANVAS framework, which enabled the identification of the main business model components. Identifying the blockchain business cases of implementation as stress-factors, it was possible to determine which of the current business model components are more robust and which one could be affected the most. It was found that the blockchain business cases negatively impact the value offered by Portbase, as well as the customer and revenue structure. To face this potential issue of disintermediation; a set of solutions for Portbase on how to adapt its business model is developed. Based on the literature on the digital disintermediation, Portbase is suggested to play a role as an information, translation, trusted or monitor intermediary.

In conclusion, this research has identified four blockchain business cases and evaluated their relative impact on port logistics. Subsequently, these business cases were used as stress factors for the stress-test analysis to provide recommendation for Portbase on how to adapt its business model. This led to the identification of new potential roles for Portbase as an intermediary in port logistics. The results of this research are valuable since the industry is characterised by huge hype on the technology but very little is known about its application and benefits. However, this research raised some new doubts. First, is the lack in process visibility a technological issue that can be solved with a blockchain implementation or is it an intrinsic feature of the supply chain that requires a mind-shift? Second, is blockchain going to disintermediate the whole supply chain or it generates new intermediaries? These issues represent some of the suggestions for future research, which could build on top of this report with the objective to clarify the real blockchain implementation in port logistics.

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1. Introduction

1.0 Research Background

Over eight years from its conception, Blockchain is considered as a ground-breaking innovation in information technology (Abeyratne and Monfared, 2016). Known by most as the technology that enabled the wide-spread of Bitcoin, Blockchain has lately sparked a huge hype around its potential applications. It is known as the first native digital medium for value, just as the internet was the first native digital medium for information. The technology enables a broad range of possibilities: “any sort of asset registry, inventory, and exchange, including every area of finance, economics, and money; hard assets (physical property); and intangible assets (votes, ideas, reputation, intention, health data, information, etc)” (Seppälä, 2016).

Despite the technology is still in its early stages and it has not reached enterprise adoption yet, Blockchain applications advance far beyond digital currencies. Financial, health and energy sectors are just few examples of industries that can profit from the disruptive technology. As blockchain technology becomes more established in different sectors, supply chain IT experts, vendors and developers are also looking at its potential and use in the logistic sector. According to Korpela and Hallikas (2016), Blockchain represents the key element for the creation of the Digital Supply Chain. The disruptive technology is regarded as a potential means of establishing the integration of the different actors in the supply chain, enhancing the information flow among them and ensuring the security as well as the cost effectiveness.

The logistic industry just recently took the interest in technology. Several blockchain solutions for logistics are already entering the market. In March 2017, IBM, the IT company, and Maersk, the Danish shipping giant (worldmaritimenews.com, 2017) started a joint-developed project to create a blockchain platform for cargo information storing. The duo is working on a Blockchain solution able to reduce frauds and delays at customs, the time spent in transit as well as costs and waste. Similarly, TU Delft is working in a 16 partners’ consortium on a blockchain solution for logistics. The aim of the project is to develop a scalable technology to boost innovation in the Logistics Top Sector (tudelft.com, 2016). While IBM and TU Delft are working on the development of a Blockchain architecture, there are several start-ups on the market developing applications for port logistics based on Blockchain technology. As described by Brenig et al. (2016), applications are Blockchain-based software implemented on top of a given Blockchain platform to provide additional functionalities not initially available. Vawe, Solas VGM and Smartcontracts are just few examples of Blockchain applications. As an innovative player in port logistics, the port of Rotterdam is interested in inspecting the potential advantages brought by the disruptive technology, particularly by the applications that are currently on the market. Commissioned by Smartport and Portbase, this project aims to provide a clearer overview of the technology capabilities in the environment of the port of Rotterdam as well as a starting point for future research.

Today’s hype on the technology created an environment of misunderstanding among the public at large. This chaos is self-reinforced by the negative association of Blockchain with the technology that enabled illicit transactions in some early applications of Bitcoin as a currency. Moreover, the polarization of its advocates, who often regard Blockchain as a panacea for all sort of problems, i.e. “one of the most important inventions of the 21st century” (Sparkes,2017), and the apathy of its detractors, e.g. Jamie Dimon the chief executive officer

of JPMorgan Chase which define it as a “waste of time”, has contributed to increase the confusion on the topic. Therefore, this thesis aims to analyse the technology under a critical perspective, providing an objective description of the Blockchain feature, the potential use cases and the relative impact.

1.1 Research Scope: Research Relevance and Knowledge Gap

1.1.1 Definition of the Practical Problem

In 1996 the port of Rotterdam was considered the largest port in the world (Kreukels and Wever, 1995). However, in the last twenty years this leading position has been taken over by South-east Asian and Chinese ports. The change in ranking is the result of the well-known large difference between the Asian and the Western Europe economic growth rates. Therefore, the port of Rotterdam is nowadays competing at a continental level to maintain a leading position in the so-called Hamburg-Le Havre range, where ports such as Hamburg and Antwerp are growing in importance. There are many factors that affect the port attractiveness, with monetary cost and time playing a key role (Clark et al.,2001). However, when every port managers tries to keep the operational costs as low as possible, the so-called “race to the bottom”, the services offered by the port can be the real competitive advantage from competitors. The availability of information to every company in the process, the network of companies operating in the port and the port efficiency as defined by Tongzong and Heng (2005) are key port services that can play a difference in competitiveness.

In 2008, the Port Community System (PCS) was implemented at the port of Rotterdam with the aim to share data in an easier, convenient and reliable manner. Nowadays, this IT infrastructure links more than 2400 companies operating throughout the world, from the shipping companies and freight forwarder to the rail operators and haulier. Despite the large competitive advantage brought by PCS, the port of Rotterdam is still lacking an integrated approach towards managing all aspect of the supply chain, i.e. coordination of the physical, financial and information flows. Together with the PCS, several other information technologies arose in the port ecosystem creating a business case where information are scattered and process visibility is absent. Moreover, in cross chain collaborations the information sharing between the supply chain members is a cumbersome process that the PCS in not able to simplify. The numerous transactions between members located in different geographic location leads to the creation of redundant and inaccurate data. This process information is stored in a wide variety of not connected systems located around the port of Rotterdam and in the hinterland. This situation may cause delays in cargo and trade flows, which lead to a longer lead-time of the process. These inefficiencies represented a window of opportunity for new IT solutions that offer advanced functionalities. Blockchain is considered by many one of these ground-breaking solutions, which is able to disrupt the worldwide supply chain by removing the third parties and enhancing the process visibility. Therefore, it has the potential to threaten the current business model of Portbase, which is the company currently managing

the information flow at the port of Rotterdam. The objective of the company is to optimize cross chain collaborations, offer better services to the companies operating in the port and, as a consequence, maintaining its role of information flow manager.

To sum up, this research will address challenges that the IT experts at the port of Rotterdam are facing when assessing the benefits brought by blockchain technology. More precisely, it will evaluate the impact of the technology under a port logistics perspective, by analysing the potential benefits on the physical, financial and information flows. The starting point of this thesis research consists in an analysis of the blockchain technology and the current port processes. Second, this study will evaluate the technology functionalities proposed by the current market applications deriving potential business cases of implementation. Third, these business cases will be evaluated based on a port KPI's analysis framework and the technological impact on the port environment will be defined. Finally, considerations on the blockchain's impact to Portbase business model will be provided.

1.1.2 Definition of the Scientific Problem

The current literature does not provide any clear definition of blockchain, since the technology is presented in several variances and applications. A blockchain solution can be public and private, anonymous or based on user's reputation with a validation mechanism that can be centralized or decentralized. These are just few examples that show the broad spectrum of different technologies identified with the word "blockchain". This confusion on the technology definition generates lack of understanding on the potential uses of blockchain in port logistics as well as its real benefits. The first scientific problem in the field of the research is the evaluation of the fundamental Blockchain's properties that can be turned into applications in the field of logistics. The idea at the base of the technology is the concept of "distributed transactional database" spread into different nodes of the network (Morabito, 2017). These nodes, which identifies different users, work together in the creation and storage of an encrypted sequence of transactional records, which is defined as "block" (Lemieux, 2016). The technology is expected to bring a substantial transformation in the logistic sector, based on the following characteristics:

- **Transparency:** Blockchain may prevent the creation of organizational silos within existing parties of the supply chain, enabling the different actors involved in the process to access the information. This feature leads to univocal, shared and real-time accessible pieces of information. Instead of having data buried in legacy silos, ERP or TMS, data are accessible in a distributed and decentralized way to supply chain members;
- **Traceability:** Blockchain is able to keep track of the different processes so that every supply chain member is able to produce or collect information about the product's lifecycle (supplier information, the manufacturing process information, logistics information and others). This not only provides a guarantee over the product's origins, but it also offers information about the requirement for the product's handling, transportation and storage. Finally, this feature enables an easier traceability of the causes and responsibilities for problems occurred in the process;
- **Security:** The information is stored in a ledger, which is a distributed data structure where transactions are organized in blocks (Kiayias et al., 2016). Each block is secure by encryption based on a hash mechanism so that the ledger becomes a proof-of-work

puzzle. The access to information is based on a key system. Therefore, every member of the blockchain, the so-called “node”, is provided with a private key and a public key, which enable him to access the private information and the Blockchain respectively;

- **Built-in-trust:** The feature of encryption on which Blockchain is based represents the guarantee of trust towards the system. This enables the members of the blockchain to bypass the third parties that serves as a guarantee of financial, physical and information transaction in today’s supply chain. In logistics, this leads to the elimination of documents such as Bill-of-Landings, Letter-of credits and middlemen such as Freight forwarder and banks.
- **Real-time accessibility:** Blockchain provides to every user with authorization a real-time access to the information. This faster and broader access to information leads to speed-up the logistic processes and avoid bottle-necks. Benefits are not only related to the information flow, but also to the financial flow.

The implementation of blockchain on port logistics opens the discussions on the efficiency and efficacy of the current port Inter-Organizational Information System (IOIS). The IOIS refers to an information and communication technology that connects two or more autonomous organizations around a common IT infrastructure that facilitate the creation, storage, transformation, and transmission of information across organizational boundaries (Johnston & Vitale, 1988). A blockchain implementation would imply a shift from the architecture of the central Orchestration hub that is currently held by Portbase, to a distributed plug and play architecture (Srour et al., 2008). This change not only has the potential to deeply modify the current processes, but it also gives rise to a new set of possibilities and business opportunities (Subramani,2004). To this matter, the current research aims to analyse the blockchain under the IOIS perspective to evaluate the power of the technology to accomplish this use.

Blockchain is a relatively new technology and there is still misunderstanding on the potential applications and impact in the field. The research makes use of the concept of Business Model and Business Model Innovation to evaluate the technological impact on the port IOIS. These concepts will serve as a base for a Business Model Stress Testing analysis, which is a tool to evaluate the robustness of a company’s BM to external factors. Evaluating the impact of a collection of alternative business cases, this tool identifies the BM’s components on which the technology can have a major impact. Business Model Stress Testing was introduced for the first time by De Vos (2012) as a tool to evaluate the robustness of a company’s BM by evaluating the impact of a collection of alternative environments.

This research aims to contribute to the branch of the literature on business models, which identifies the relationships between emerging technologies and company’s business models. Currently, the literature presents a double perspective on the topic. On the one side it can be viewed as inputs that are converted by the company in products or services to realize economic value (Chesbrough and Rosenbloom, 2002). Therefore, the inherent value of a technology is latent until it is commercialized. On the other hand, it can be viewed as a change in the business environment that requires companies to adapt their business models (de Haaker et al., 2017). In this second perspective, a new technology is just one of the environmental forces that affect the company’s BM.

To conclude, this research aims to fulfil the theoretical and practical research gap on Blockchain potential on port logistics. It plans to do that by providing an in-depth evaluation of the technology and the current market applications to clarify the use-cases in port logistics. Moreover, this research aims to identify the technology’s role at port inter-organizational information system by assessing its potential in terms of information and physical flows optimization.

1.2 Knowledge Gaps and Research Contribution

After identifying practical and scientific problems, the main knowledge gaps can be deduced and research relevance can be emphasized. First, blockchain technology is a new and complex phenomenon, which is gaining much attention from the various industries and academics from different disciplines. IT experts and many consultancy companies are classifying the technology as a disruptive technology, which has the potential to change the future of port logistics. However, not much is actually known about the benefits brought by the technology to the logistics sector. Mostly only potential future use cases are described, with no further evaluation of feasibility or critical perspective on potential barriers. Therefore, this research project contributes in expanding the current literature on blockchain technology in application to port logistics and defining the expected impact of blockchain use/cases in the field.

This research will focus on exploring blockchain potential for operational and informational process optimization in port logistics domain. The topic of the research is interesting in its timeliness: there is hype around the blockchain technology, yet there is very little knowledge of its actual application in the logistic sector and of its potential in process improvement. This research aims to provide recommendations to Portbase on the benefits brought by the technology in terms of information flow optimization. Moreover, studying the role of the current port's inter-organizational information system managed by Portbase, the research aims to analyse the areas of the business model that will be disrupted the most by the technology implementation.

1.3 Research Objective and Research Approach

1.3.1 Research Objective and Research Question

To identify the impact of blockchain technology on port logistics, two goals are defined alongside the research objective. The research objective is stated as follows:

The aim of the research is to identify the contribution of Blockchain on port activities and *evaluate the impact of the technology on Portbase's business model.*

The first objective in this research is to determine the main blockchain business cases of implementation in port logistics to identify the technological impact. Second, this research aims

to evaluate the Portbase's business model components that are affected by a blockchain implementation to derive some recommendation for the company.

The research objective has been translated into one main question supported by four sub questions. The sub questions are meant to contribute in answering the main research question. From the research objective, the following research question can be derived:

How does blockchain technology affects port logistics and what is the impact on Portbase's business model?

In order to answer the main research question, an initial literature review is necessary to provide a research background on the topic. This yields to the first sub question:

SQ1: What are the key features of the blockchain technology in application to port logistics?

First question addresses a theoretical background on the blockchain ecosystem. Based on the scientific literature review the evaluation of blockchain technology and its key features in application to port logistics will be identified. The technology analysis will be structured by distinguishing among the blockchain platform, and applications built on it. The technological understanding of this first sub-question set the course for the second sub-question:

SQ2: What are the potential use-cases of blockchain in application to port logistics and what are the port performance indicators to evaluate them?

The second question addresses the identification and evaluation of the key blockchain applications in Logistics. First, the key applications and their features are described. Second, the applications will be grouped in categories based on the proposed functionality. Third, a list of port performance indicators will be selected from the literature to evaluate to impact of each blockchain business case.

SQ3: What is the impact of the blockchain use cases on the port processes in terms of information, physical and financial flows?

The first two sub-questions provide an understanding on blockchain and its potential applications on port logistics. The next step consists in the evaluation of each use-case's impact in terms of information, financial and physical flows. The focus of this analysis is the import carrier process, which starts with the carrier approaching the port of Rotterdam and it concludes with the container loaded in a transport (truck, train, or barge) towards the hinterland.

SQ4: What is the current Portbase business model and how can it be adapted to a blockchain implementation?

The fourth question addresses the evaluation of the Portbase's business model. First, an introduction of business model innovation and business model stress-testing tool will be provided. Second, a detailed description of the company's business model is defined. Third,

the stress factors relative to a blockchain implementation will be identified. Fourth, the business model's components mainly disrupted by the technology are evaluated and recommendations provided.

1.4 Research Approach

This research has an exploratory nature and it follows a qualitative approach, using both primary and secondary data. Figure 1 elaborates on the methodological approaches taken in this research and it identifies the main steps that need to be taken in order to answer the research questions. To this purpose, the research makes use of a combination of different research methods. However, the different methods used will be shaped in the “case study” framework, according to the guidelines provided by Yin (2009).

Figure 1.1 provides a visualization of the methodology used in this research project. First, an in-depth literature review on the topic of blockchain was provided to evaluate the available knowledge on the practical issue. Second, a specific literature review on interorganizational information system and business model innovation was preliminary for the two objectives under analysis, respectively, the impact of blockchain on port logistics and the effect of the technology on Portbase's business model. This double objective is maintained also in the case study analysis. The impact on logistics is evaluated by creating a KPIs-business cases testing analysis, while the impact on the company's business model identified performing a business model stress test analysis.

This section provides a brief description of the approach used in this research project. An in-depth analysis of the tools and research methodologies used in this research will be provided at the beginning of every chapter. However, this research can be subdivided in five main steps as shown on table 1.1.

Table 1.1: Research Methodology Steps

Research Step	Aim	Relative question	Sub-Input	Result
Step 1 Literature Review	Provide general understanding on the topic and inspecting available knowledge for evaluation tools	SQ1: What are the key features of the Blockchain technology in application to port logistics?	Available Literature Desk Research	Theoretical Background
Step 2 KPI Selection	Identification of relevant KPIs preliminary for the business cases testing.	SQ3: What is the impact of the blockchain use cases on the port processes in terms of information, physical and financial flows?	Available Literature Case Study	List of KPIs to evaluate physical, financial and information flows

Step 3 Business cases Building	Categorization of the main blockchain functionalities into technology use-cases	SQ2: What are the potential use-cases of blockchain application to port logistics and what are the port performance indicator to evaluate them?	Desk Reserach Case Study	Categories of blockchain use-cases
Step 4 Business cases Evaluation	Evaluation of the business cases' impact on port process flows	SQ3: What is the impact of the blockchain use cases on the port processes in terms of information, physical and financial flows?	Semi-structured expert Interviews Case Study	Blockchain impact on port logistics
Step 5 Business Model Stress Test	Evaluation of the current business model components and evaluation of the blockchain impact on them	SQ4: What is the current Portbase business model and how can it be adapted in case of a blockchain implementation?	Desk Research Focus Group	Business model description Stress-test

1.5 Case-Study

Qualitative case study research represents the main methodology used in this research project. To insure an appropriate use of the research method, the study is rooted in the techniques introduced by modern case study methodologists such as Stake (1995) and Yin (2009). The unit of analysis of a case study is tied up to the research question. It consists of Portbase, the private company managing the port information system (Port Community System) for the two major Dutch ports (Port of Rotterdam and Port of Amsterdam). This unit of analysis provides a double perspective to evaluate the technology's implementation in port logistics. On the one hand, it enables the researcher to achieve a broad and unbiased understanding on port activities. This is justified by the neutral position of Portbase in commercial activities and the broad spectrum of the company's activities in the port. On the other hand, it enables the researcher to inspect the extent to which the business model of private companies operating in the port are affected by the technology implementation

To evaluate the blockchain impact on port logistics, the import carrier process at the port of Rotterdam was selected. The case-study was helpful to inspect the information, physical and financial flows of the container flow within the port environment. The identified process starts when the carrier is approaching the port of Rotterdam and it finishes when the containers are loaded on to barges, trains or trucks for the hinterland transportation. This process is characterised by more than forty parties involved and a large amount of information exchange among them. In collaboration with Portbase, I selected some of the critical process steps to evaluate whether Blockchain can play a role in improving the process efficiency.

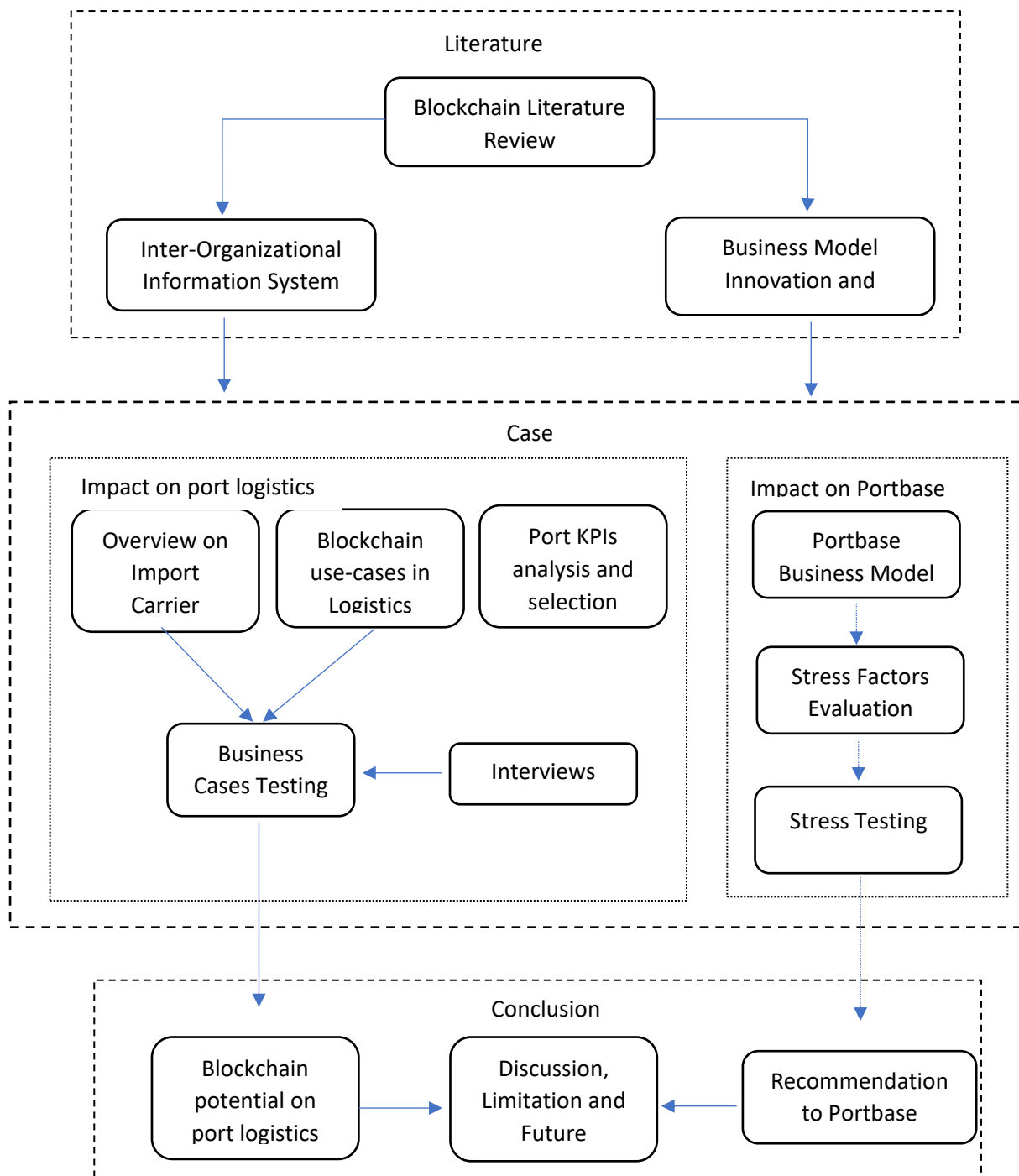


Figure 1.1: Visualization of the steps taken in the research project

1.6 Thesis Structure

This chapter served as an introduction to the topic and objective of this research project. The structure of the whole thesis can be visualized in Figure 1.2.

Chapter 2 provides an extensive literature review, which focuses on the concept of blockchain and port inter-organizational systems. In particular, the blockchain literature review differentiates between blockchain platforms and applications to understand the main features of the technology at stage. Chapter 3 describes the case study of the import carrier process at the port of Rotterdam, which is the research domain of the thesis project. Chapter 4 describes the methodology and the tools used to build the analysis. Therefore, the KPI selection and the business cases building will be presented. Chapters 5 and 6 describe and analyze the results. The main findings consist of the KPIs-business cases analysis and the Portbase's business model stress-testing. Chapter 7 provides some conclusions based on the findings as well as limitation on the research.

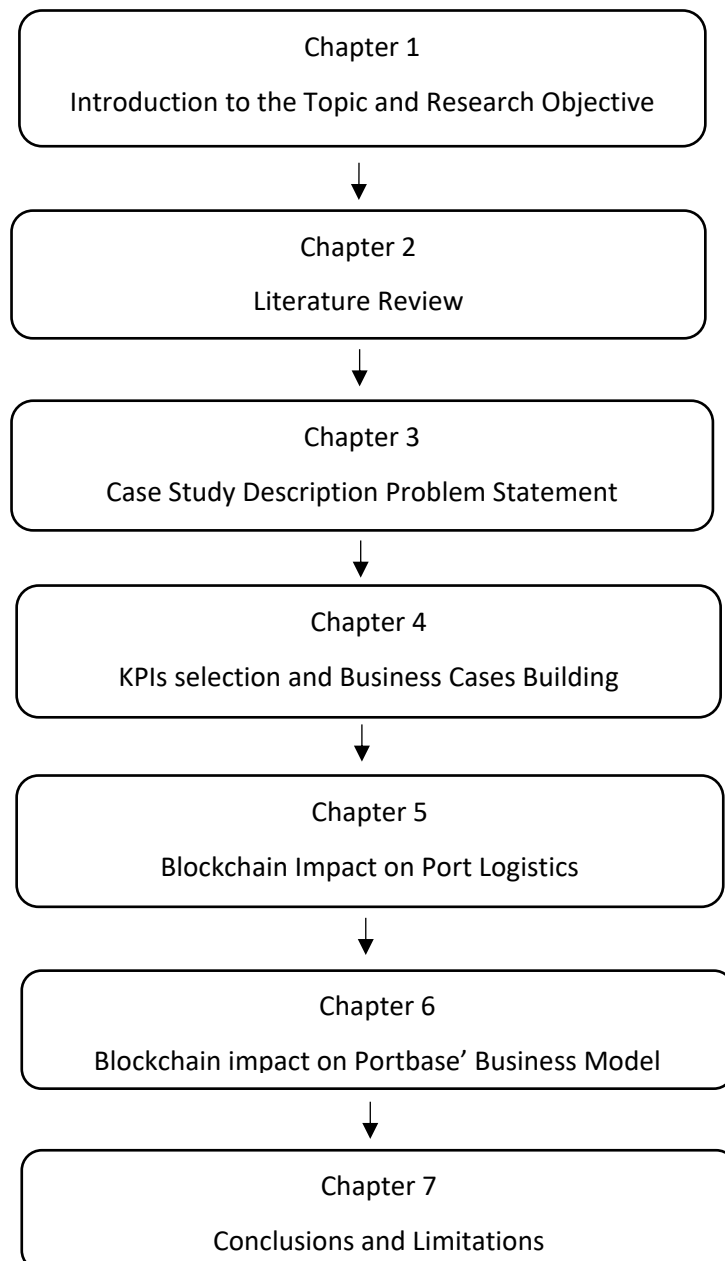


Figure 1.2: Visualization of the thesis flow

2. Literature Review

This chapter provides an overview of the current literature on the topic of blockchain and inter-organizational information system. This double focus of the literature review is justified by the research objective. Many practitioners identify the technology as a substitute of the current port information system (Port Community System). Therefore, this research aims to evaluate potential blockchain use-cases and their impact on the port operations, to evaluate whether information flow can benefit from a blockchain solution. To this end, this literature review is divided in two sections. First, a literature review on the topic of inter-organizational information system helps to understand the current role of Portbase and the potential room for a blockchain implementation in the port environment. Second, a literature review on blockchain technology helps to clarify the technology' features, the working mechanism and the potential applications.

2.0 Methodology

This second chapter consists in an extensive literature review on the theoretical concepts of blockchain and inter-organizational information system. First, the literature review on inter-organizational information systems was performed to evaluate the current information system at the port and the future role of blockchain. It was carried out by using the following search engines and databases: Google Scholar, Science Direct, Web of Science, TU Delft Repository, Google. The research will be centred on the following key-words: "ITC and logistics", "port Inter-Organizational Information System". Second, the literature review on blockchain technology aims to answer the research question: "SQ1: What are the key features of the Blockchain technology?". This second research will be centred on the following key-words: "Blockchain Technology", "Blockchain Platform", "Decentralized Architecture".

2.1 Information Technology at the Port of Rotterdam

This section aims to provide an overview on the concept of Inter-Organizational Information System (IOISs). It opens with a description of the new role played by the port in today's logistics, which represent the environment for the IOISs blossoming. Second, an extensive literature review on the topic is provided to define the concept and its evolution in time. Third, the main IOISs architectures are defined and the purpose for implementation specified. This understanding on the concept will be useful in the following stage of the research to evaluate the role of the Port Community System (PCS) and the potential impact of blockchain.

2.1.1 The port in the global supply chain

The maritime transport plays a key role in today's world economy as over 90% of the world's trade is carried by sea (Business.un.org, 2017). Despite this already considerable importance on the world economy, the seaborne trade volume is growing at a rate of approximately 5% per year and it does not seem to stop any soon (Unctad.org, 2016). This trade growth not only turns ports into vital logistic hubs, but it requires them to operate in a more efficient and smarter way than ever before. Therefore, ports are asked to rethink and adapt their role based on these new market challenges. Today's port operations are characterised by a large complexity increased by the several actors playing a role in the port processes. For instance, the import carrier process sees more than ten different stakeholders involved in the movement of the container from the vessel to the hinterland transportation. Therefore, large ports are required to develop advanced coordination methods able to facilitate and standardise the information exchange among the parties and, subsequently, increase the port throughput rate. Lee et al. (2015) identified new IT solutions as the major factor for improving the process coordination, towards the creation of the so-called "economy of flow" or "economy of connection". The new economies aim to increase the knowledge and information sharing among the process stakeholders; generating economies of coordination; developing joint R&D project between the private and the public sectors; and obtaining mutual benefits from the combined use of complementary assets and knowledge.

Information sharing and the process standardization can be achieved through a unified information system that addresses the high complexity of port processes (Posti et al., 2011). The literature uses the term "Inter-Organizational Information Systems" (IOIS) to define the information system that connects two or more companies with the aim of facilitating the communication among them. In other terms, IOIS are information systems that span the boundaries of a single organization (Chatterjee and Ravichandran, 2004). The potential of these information systems to lower the operating costs, boost the service quality and, consequently, improve the organization's competitive ground is significant (Clemons and Row, 1993; Reekers and Smithson, 1996). Thus, such systems are able to boost not only the single organization's competitiveness, but also the competitive position of the entire network of firms linked through the system.

2.1.2 Inter-organizational Information Systems

The concept of Inter-Organizational Information System (IOIS) can be traced back to 1966, when Kaufman saw that computer networks having the potential to improve the collaboration and coordination between different organizations in the supply chain in terms of billing and payment practices. In 1982, Barrett and Konsynski used the term "IOIS" for the first time to define the information system able to inter/intra-connect one or more independent organizations (Barret and Konsynski, 1982). Few years later, the IOIS was described as "an automated information system shared by two or more companies" (Cash & Konsynski, 1985, p. 134). In the late 1980s Johnston and Vitale (1988, p.154) expanded this concept as: "An IOS is built around information technology, that is, around computer and communication technology that facilitates the creation, storage, transformation and transmission of information. An IOS differs from an internal distributed information system by allowing information to be sent across organizational boundaries". Therefore, IOIS enables and

facilitates the cooperation among the members of a network making them tightly coupled in order to get similar efficiency as vertically integrated hierarchies (Wilson and Vlosky, 1998). In other words, the IOIS work as links between separately owned organizations (Holland, 1992) to increase the efficiency of the global chain.

Early research on IOIS strongly focused on the exploration and definition of the technical attributes of the Information System, as pointed out by Henriksen (2002). The unit of analysis of these first studies was the micro-level business-to-business interaction. The criticism of Johnston and Gregor (2000) triggered a shift from this narrow perspective towards the implications of IT for large network of organizations and the impact of IOIS on entire industries (Johnston & Gregor, 2000; Markus et al., 2006; Steinfield et al., 2005; Wigand et al., 2005). As a consequence, other aspects of IOIS took relatively large interest from academia, such as socio-political traits that influence the collaboration across organizations (Damsgaard & Lytinen, 1998) and across multiple levels (Rukanova et al., 2009).

The most recent literature reviews of the field of research are the work of Chatterjee and Ravichandran (2004) and Robey, Im and Wareham (2008). Both articles identify the research on IOIS as composed by three main areas of investigation: 1) Antecedents of organizational adoption of IOIS; 2) Impact of the IOIS on the transactions governance structure; and 3) Organizational consequences of IOIS adoption.

In the following paragraphs, we will first define the IOIS structure. Second, we will define the scope of implementing a IOIS to connect a group of organizations.

2.1.3 Inter-Organizational Information Systems Structure

The Interorganizational Collaborations are made possible by a technology layer that connects two or more geographically disparate organizations. The structure underlying this

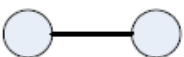
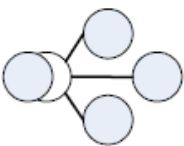
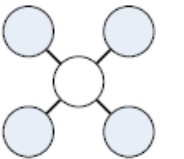
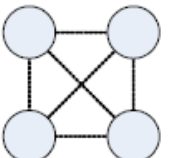
Architectural Type	Explanation
 <p>Bilateral (1:1)</p>	<ul style="list-style-type: none"> • Point-to-point (P2P) connectivity. • Direct connection between two trading partners. • Connectivity in its most basic form. • Works well for established partnerships.
 <p>Private hub (1:N)</p>	<ul style="list-style-type: none"> • Hub structure that makes it possible to connect to many partners with minimal linkages. • Internal applications need only one connection point. • Standardized access for external partners. • Generally initiated by a strong party, to link with many smaller parties
 <p>Central orchestration hub (N:M or N:1:M)</p>	<ul style="list-style-type: none"> • Like a private hub; but generally run by independent operator. • Expected to work best in industries without dominant parties.
 <p>Modular distributed plug & play architecture (N:M)</p>	<ul style="list-style-type: none"> • No permanent linkages – plug & connect capabilities. • Parties connect when interaction needed, exchange information and conduct business. • Standardization is critical.

Figure 2.1: Four Different Architectural Types (Baalen, 2008)

transactional backbone is called architecture (Srouf et al., 2008). The literature classifies four different types of architectures (Figure 2.6):

- Bilateral represents the first type of IOS enabling one-to-one connections. Examples of this easy and cheap communication method are the phone, fax, and Electronic Data Interchange (EDI). This architecture is easy to implement and it enables the parties in the transaction to design their own message format. However, it suffers of scalability since $n(n-1)/2$ connections are required to interconnect n parties (Baalen, 2008);
- Connecting every party to a hub requires a fewer number of connections, since these connections are established through the hub. Therefore, n parties implies n connections. Private hubs are owned by a central party which connect the different parties to the outside world in a one-to-many structure;
- Central Orchestration hubs do not belong to any of the parties of the network and they are characterized by a many-to-many structure;
- The modular distributed plug and play category is not truly established yet but it consists in the use of internet to fast connect with parties in the supply chain that you do not know directly (Srouf et al., 2008). Blockchain represents a valuable example of this architecture category.

2.1.4 Inter-Organizational Information Systems Purpose

In logistics, the Information Technology (IT) lays behind the creation of the global supply chain. Information and communication have facilitated geographically dispersed production and distribution chains. Moreover, IT has enabled companies to track and trace the location of products along the supply chain. To clarify the final purpose of IT solutions in trade flows Subramani (2004) differentiated between two perspectives: exploitation and exploration. The former refers to the group of actions aimed to improve operational efficiency; while the latter indicates the set of actions aimed to discover new possibilities. Although Inter-Organizational Information Systems (IOS) could be utilized to explore new possibilities, most of the applications in port logistics just focus on the exploitation perspective. In other terms, many applications in port logistics exploit the IOIS to smooth the physical flow of goods (Baalen et al., 2008). Similarly, the PCS was integrated in 2007 with the objective of automating and improving the port information and physical flows (Srouf et al., 2007).

2.2 Technology overview

This section aims to provide a background on blockchain technology in order to clarify the working mechanism, the key aspects, and the main applications. It aims to provide a technological framework that will work as a base to understand the following chapters of this thesis research. The technology description is shaped according to the framework provided by Brenig et al. (2016), who structures the technology into platform, application and services (Figure 2.1).

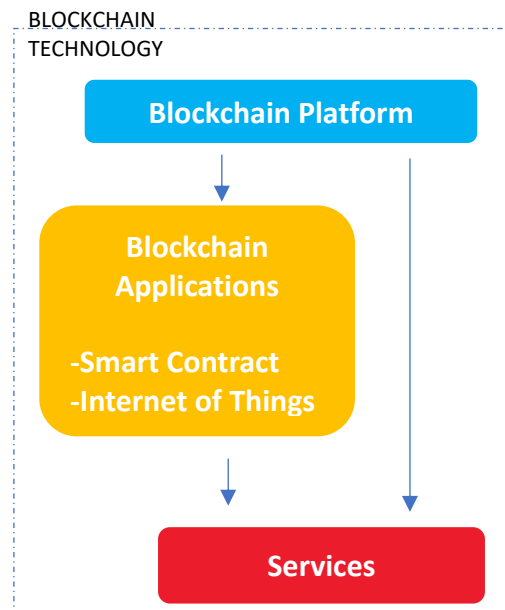


Figure 2.2: Framework for blockchain analysis (Brenig,2016)

- The **blockchain platform** is identified as a “decentralized consensus system” (Brenig et al. 2016). There are different standards of blockchain technology on the market. For instance, the technologies working as the backbones of Bitcoin and Ethereum introduce different standards and they represent different platforms, even if they are both decentralized consensus systems.
- The **blockchain applications** are implemented on top of a given platform, being connected by a technical link to a specific blockchain, to provide additional functionalities not initially available.
- The **blockchain services** do not require a technical link to the blockchain and they make use of the existing functionalities of a blockchain or an application more effective.

2.2.1 The Blockchain Phenomenon

Before further discussion on blockchain technology, it is ideal to provide an overview on the first blockchain application, Bitcoin. Born in 2009, Bitcoin Blockchain aims to revolutionize the worldwide payment system. It consists in a virtual currency transacted among users, also defined as nodes, participating to the Bitcoin network. Compared to other virtual currencies, Bitcoin has obtained a relatively wide spread since it first solved the issue of “double spending”. This risk consists in making a digital transaction while keeping the original copy of the transacted asset. To solve this risk, Bitcoin Blockchain is based on a “distributed ledger scheme”, which substitute the trusted centralized intermediary in its role of recording every transaction carried out.

Many people erroneously consider “Blockchain” and “Bitcoin” as interchangeable terms for the same technology. However, according to the definition provided by Brenig (2016), Bitcoin represents just one of the several possible application of a Blockchain technology. In other words, Blockchain represents the technological backbone of Bitcoin, the platform on which Bitcoin is built. Since the aim of this research is to analyse the Blockchain technology, we are not interested in describing the application Bitcoin. However, it is relevant to describe those

peculiarities that characterise Bitcoin Blockchain as a platform. Therefore, while describing the different features of a Blockchain platform, we will refer as Bitcoin Blockchain as an example to facilitate the understanding.

2.3 Blockchain Platform

The aim of this section is to provide a clear definition of Blockchain platform by analysing the key building blocks that compose it. Following the characterization of Mougayar (2016), the blockchain platform can be identified as the protocol of the technology, which is the foundational base for the other two layers (applications and services). It consists of the infrastructure that works as technical backbone of applications such as Bitcoin and Ethereum. Building on the definition provided by Glaser (2017), this research identifies blockchain platform as:

Blockchain is a transactional database, which is distributed among nodes linked in a peer-to-peer (P2P) communication network. The access to the network is based on a permission mechanism, which enables the nodes to perform transactions that hold validity based on a consensus mechanism. (Glaser, 2017)

The following paragraphs provide a description of the technical building blocks of the Blockchain platform with the aim of providing an overview on the technical aspects behind the current and the future potential market applications. The Blockchain platform description is structured on a top-down approach starting with the description of the network structure. Second, the ledger architecture will be analysed and decomposed in blocks and transactions. Third, the transaction mechanism will be presented to provide a general understanding on the Blockchain working procedure. Fourth, the permission mechanism will be defined. Fifth, the different consensus mechanisms will be described.

2.3.1 Network Architecture

The key feature of Blockchain technology resides in its distributed nature (Swan, 2015). Different from centralized and decentralized networks, a distributed computing network system is a system where data and resources are spread out on various hardware nodes. Moreover, each node maintains a database of historical and valid transactions, which are sent among the nodes in the network (Figure 4). Despite every node holds a copy of the ledger, only those users that hold the signature on it can access the information. As described by Morabito (2017), the blocks composing the shared ledger can be seen as containers where data is stored. However, these containers are sealed and their content can only be seen by those who hold the permission.

The nodes identify each other by their IP address, while users address to each other through their public key. Each node represents a physical/virtual machine that communicates via TCP/IP with other nodes (Glaser, 2017). Therefore, each node can send a transaction to every other node in the network if it knows the receiver's public key, without any central authority involved in the transaction.

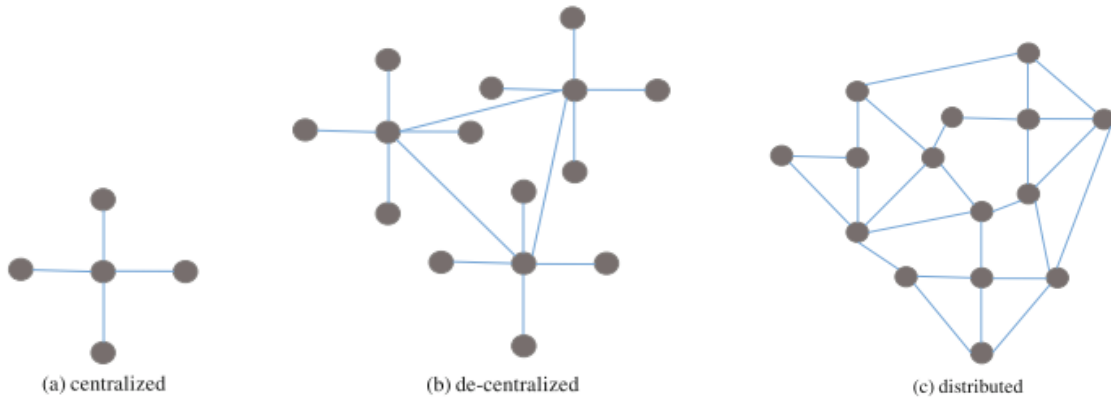


Figure 2.3: Centralized (a), De-Centralized (b) and Distributed (c) networks comparison (Morabito, 2017)

The absence of a central server strengthens the system’s security, since it makes more difficult for a network to experience attacks such as client related attacks or service denial attacks. Moreover, altering a transaction of the chain requires huge hash-recalculations for every block registered after the modified block, leading to an improved security protection. Therefore, the blockchain is built on a consensus mechanism, which represents a trust-worthy invisible authority (Xu, 2016).

Despite terms like “miners”, “validators” and “full-node” are erroneously used interchangeably in the different applications, it is necessary to make a distinction. Meijer (2017) noticed that not every node has the same power on the blockchain and he provided a clear distinction of powers:

- Users that read data: Those that store the blockchain and have access to the data.
- Users that write data: Those that not only store the blockchain and have access to the data, but they can send and receive transactions via the Blockchain.
- Users that validate data: Those that validate the transaction that are sent to the blockchain.

2.3.2 Ledger Architecture

Blockchain ledger can be described as a string of blocks, which include a detailed list of transaction record similarly to a conventional public ledger (Chuen, 2015). Figure 2.3 provides a visualization of the blockchain. Each block is composed by a block-header and a block-body. On the one hand, the block-header contains the information on the previous and following block-header hashes, as well as the time-stamp. On the other hand, the block-body is composed by the number of transactions and the collection of transaction, which have inputs and outputs.

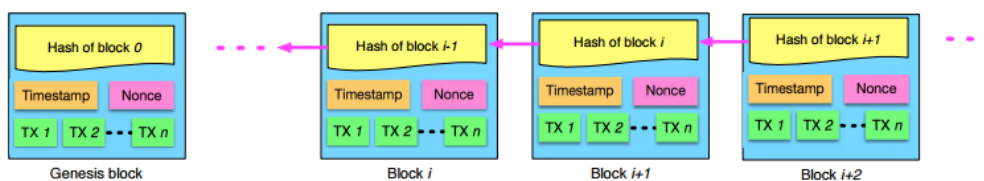


Figure 2.4: Blockchain visualization (Zheng et al., 2016)

Each node in the network holds a set of keys, a private one and a public one. The private key is used to encrypt the transactions before sending them, as shown in Figure 3. To send a transaction, the sender needs his private key and the receiver's public key. Moreover, before being recorded on the Blockchain, the transaction needs to undergo two phases: a signing phase and a verification phase (Figure 3). On the one hand, the sender's encryption of the data with the private key is defined as the signing phase. On the other hand, the verification phase consists of the solution of a computational problem which ensures that the same transaction is not happening twice (Morabito, 2017).

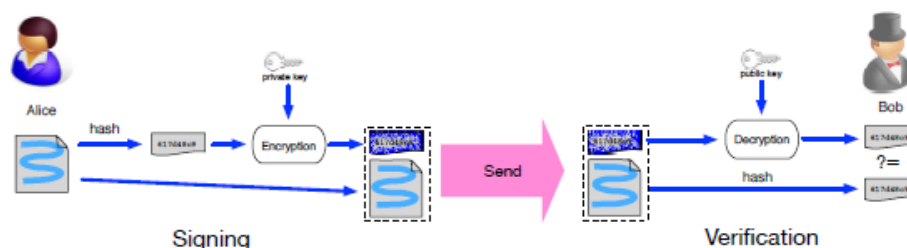


Figure 2.5: Digital Signature mechanism (Zheng et al., 2016)

2.3.3 Blockchain Transaction Mechanism

The transaction mechanism can be described in five key phases (Froystad P. and Holm J., 2016):

- Transaction Definition: The sender generates the transaction specifying the details of the receiver's public key (it consists of the receiver's address) and the value of the transaction. Moreover, this transaction has to be authorized with the sender's cryptographic digital signature, which proves the digital authenticity (Morabito, 2017).
- Transaction Authentication: Once sent to the network, the transaction is received by the nodes, which authenticate the message validity by decrypting the digital signature. This transaction is waiting in a pool of pending transactions until a block is created (Froystad P. and Holm J., 2016).
- Block Creation: A node of the network takes charge of the transaction by combining it with other pending transactions and creating a block, which is an updated version of the ledger. Once created, a block is broadcasted to the network for validation.
- Block Validation: The nodes in charge of validating the block receive the proposed block and they start an interactive process to validate it. However, there might be a divergence among blockchain's branches when the different nodes do not share the same perspective of the entire network state. Therefore, it is necessary to reach a consensus on the block validity among the different nodes based on a validation technique. As previously described, Bitcoin Blockchain is based on a "Proof-of-work" mechanism, while Ethereum is built on "Proof-of-stake". Despite of the consensus mechanism chosen, this phase ensures the validity of every transaction avoiding fraudulent attempts of transaction (Zheng et al., 2016);

- Block Chaining: Once every transaction recorded in a block has been accepted, the new block is registered on the network being linked to the last block chained in time. The updated chain is then broadcasted to the network, which accept it as the verified version of blockchain on which future blocks will be recorded. (Froystad P. and Holm J., 2016)

2.3.4 The 4 Ps of the blockchain

The original blockchain concept developed by Satoshi (2008) was a fully public one, 100% de-centrally controlled. However, this structure is not applicable for all possible timestamped ledger applications. Different applications require different levels of security. Therefore, a classification of the different blockchain architecture styles can be made based on a two-dimensional classification system: public/private and permissioned/permissionless.

The distinction between public and private blockchain is played at a level of platform accessibility. A platform configuration that gives room for transactions to be made by everyone is defined as “public”. The single user does not require any third-party’s permission to join the network. On the other hand, “private” blockchains involve a limited number of users who can read and access the data. The participants to the blockchain are known and trusted.

The distinction between permissioned and permissionless blockchains is based on the rights to write and vote on the platform. In a ‘permissioned’ ledger only a limited number of approved network participants can propose updates of the ledger and participate in verification. This contrasts with permissionless ledgers (of which the ‘Bitcoin Blockchain’ is the leading example) where anyone has equal rights to propose updates to the ledger and participate in the block verification.

The different public/private and permissioned/permissionless blockchain configurations are analysed in further details as follows. However, the specific configuration, which involves private access to the information and permissionless right of writing and voting on it, is not considered due to its scarce application in the market.

- Permissionless Public Ledger: It is accessible by any user (unknown/untrusted), who can access the ledger, conduct transaction and write on the ledger. These platforms are characterised by many untrusted/unknown miners or validators (i.e. Bitcoin Blockchain or Ethereum);
- Permissioned Public Ledger: These systems are created on behalf of a community of interest, where a limited number of authenticated participants have access to the ledger. These platforms are characterised by multiple trusted/known miners or validators (i.e. R3, Ripple, IBM Hyperledger);

- **Permissioned Private Ledger:** The access is given exclusively to a defined community of known and trusted users, who are the only that have access and can contribute to the ledger. These platforms are characterised by single (sometimes the community can designate an authority) or multiple trusted/known miners or validators (i.e. Chain, Bankchain, Setl, Domus Tower).

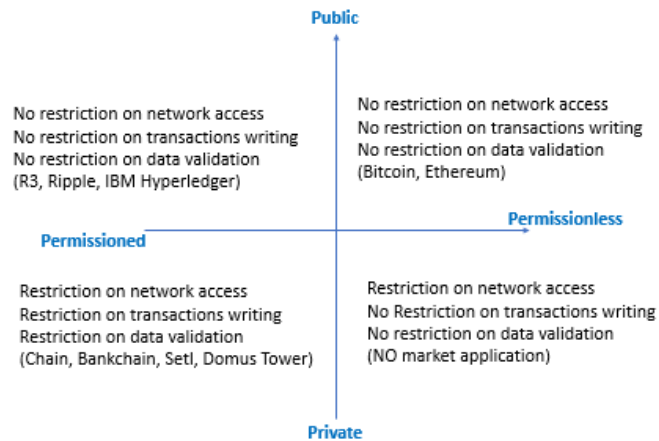


Figure 2.6: Matrix to plot data access and writing/validation restriction

2.3.5 Consensus Mechanism

Blockchain platform is a system that utilizes cryptography to secure transactions in a verifiable ledger of records. This concept leads to a redefinition of the intermediary’s role as a guarantee of the system validity. The trust does not more rely on a third-party but on a consensus mechanism. As defined by Swanson (2015), the “consensus mechanism is the process in which a majority (or in many cases all) of network validators come to agreement on the state of a ledger”. Therefore, it consists in the set of rules and procedures that allows the multiple participating nodes to trust the system. Technically, a consensus algorithm enables the use of pre-defined state transition rules as a method to tightly update states, where the state transition is disturbed and decentralized in every node (Buterin, 2014). As described by Morabito (2017), an effective consensus mechanism has to be based on three key concepts:

- Common acceptance of laws, rules, transitions and states in the Blockchain;
- Common acceptance of nodes infrastructure, methods and stakeholders that apply these laws;
- Common perception of identity that all the nodes accept and comply to the same rules.

There are multiple alternative consensus mechanisms which have been developed over the past three decades. The Bitcoin blockchain is based on the “longest chain” mechanism where the chain with the most proof-of-work is defined as the valid ledger. However, some drawbacks or limitations to the original Bitcoin- blockchain technology (such as scalability, flexibility, confidentiality and governance) has spurred the exploration of other consensus mechanisms. New blockchain platforms are trying to create new, better scalable and more energy efficient ways to achieve the consensus among the nodes of a network. As described by Mattila (2016), examples of alternative consensus mechanisms are Proof-of-stake (more than one definition), proof-of-activity, proof-of-burn, proof-of-validation. The main consensus types are briefly described in what follows.

The proof-of-work (PoW) mechanism derives from the studies of Dwork and Noar (1993), who first introduced the network security protocol, and Back (1997), who theorized the

Hash cash proof-of-work scheme. This concept consists in solving mathematical computation to match the hash relative to the transaction with the one of last block recorded on the blockchain. However, this computational process has to be supported by a hardware, which is highly energy demanding. Multiplying the energy consumed for a single transaction times the total transactions required per second, this process results particularly demanding on resources.

The proof-of-stake (PoS) represents a valuable alternative to the PoW scheme, since it is based on a more efficient computation procedure. Despite blocks are generated similarly to the PoW mechanism, the hashing procedure is processed in a limited search space, instead of in the unlimited search space of PoW (King and Nadal, 2012). Since the transactions can be processed and registered in a shorter amount of time, the system is faster and more energy-efficient. However, this system does not come without challenges. For instance, there is the risk of centralization, since the nodes with a broad stake holding can exert a dominant role on the rest of the network.

Theorized by King and Nadal (2012), the hybrid version of PoW and PoS represents the combination of mining process of the PoW with energy effectiveness of the PoS. In this Hybrid mechanism, the block is mined by the miner with the highest coinage, which is represented by the total amount of coins owned by a miner and the span of ownership of the coin's owner. In other words, it consists in a scheme with low latency (typical of PoW) and low energy-cost (Typical of PoS) on the long run.

2.4 Blockchain Application

This section describes the applications that are built atop of the blockchain infrastructure and protocols. They are linked to the infrastructure via middleware or technical links. Moreover, they provide additional functionalities not available at the platform layer. They make use of APIs to connect to the underlying protocol or platform. For instance, Zerocoin is an application based on Bitcoin, which adds anonymity as functionality, since users' privacy is originally only protected through pseudonyms. The aim of this section is to provide an overview on the concept of Blockchain application. Therefore, we will not take the singular applications on the market and describe them but we will analyse the concepts of Smart Contract and Internet of Things.

2.4.1 Smart-Contract

Based on the definition provided by Hart and Moore (2009), contracts are agreements that provide to the parties a set of rights and obligations necessary to engage long-term relationships. Moreover, contracts are used to establish the transaction terms as well as the ownership of certain assets or values. These definitions embody the concept that relationships thrive upon trust and the contract represents a guarantee of trust (Morabito, 2017). Among the different definitions of smart contract, this thesis uses the one provided by Idelberger et al. (2016) who define the digital agreement as "a computer program that holds the terms of a contractual accord and also implements the accord while ensuring trust, transparency and understanding between parties". In other words, smart contracts are computer codes

embodied in the Blockchain, which are formulated in “*if this then do that*” structures. These computer codes are built on top of the Blockchain platform since they represent a mechanism to automatize transactions. Moreover, they will ensure a decentralized trust and they will cut out the hefty fees requested by intermediaries or brokering parties.

This concept has a particular importance in the field of logistics contracting. Smart contracts enable the automation of transactions that are not value added, creating room for enterprise-wide blockchain based solutions. Moreover, they lead to solve the inter-parties lack-of-trust issue which characterise the port activities. Not only smart contracts reduce the chance for human error or cases of fraud, but they also increase the privacy, the cost and time efficiency as well as the trustworthiness (Coy and Kharif, 2016). In the business environment, there are already companies selling smart contract solutions, such as Ethereum and SmartContract. The latter, in particular, developed a platform that is able to connect smart contracts to exogenous data, internal infrastructure and payment systems (www.smartcontract.com, 2017).

2.4.2 Internet of Things

The Internet of Things (IoT) is experiencing exponential growth in research and industry, but it still suffers from privacy and security vulnerabilities. These issues can be solved with a scalable, trustless peer-to-peer technology able to operate in a transparent and secure environment for data distribution. Therefore, blockchain technology has a large potential to become the technological platform that enable IoT implementation by delivering lightweight and decentralized security and privacy. As described by Dorri et al. (2016), three are the blockchain characteristics that make the technology a potential platform to interconnect IoT devices: decentralization, anonymity, and security. The blockchain decentralized feature ensures scalability and robustness, avoiding the issue of a single point of failure. The technology anonymity and security ensure the device’s user privacy and security against untrusted parties, who can access sensible personal information.

Combining blockchain technology with IoT could lead to process automatization using smart contracts. Chirstidis and Devetsikiotis (2016) describe the potential of connecting the “smart devices” to the network as blockchain nodes and making them communicate to the system using smart contracts. The information provided by the IoT not only can be store on the blockchain providing almost real-time data on the device status, but devices could also enable transactions themselves if connected to smart contracts. In supply chain, by simply equipping the stakeholders of the container process with a smart tracker, a GSM or LTE radio to connect to the Internet, and an installed blockchain it is possible to revolutionize the entire supply chain of containers (Chirstidis and Devetsikiotis, 2016). These enabling technologies allow devices to write approved transactions autonomously to the blockchain without prior user input, and to move the process forward with the use of smart contracts.

2.5 Findings from the literature review

The increase in volume of worldwide trades turned ports into logistic hubs. This increase in power made information sharing and the process standardization as the main objectives to be addressed by the port of Rotterdam. Therefore, Portbase was established as the port interorganizational information system, which mediate the information flow playing the role as a central orchestrator hub (Figure 2.1). Portbase was designed for exploitation purposes rather than exploration ones (Srouf et al., 2007). However, the introduction of new information technologies raised the discussion on the use of blockchain as a potential substitute to the current port interorganizational information system. To evaluate the role of blockchain in application to port logistics, this research differentiated between blockchain platform and applications. The blockchain platform consists of the infrastructure that works as technical backbone of applications and it has been described in terms of network architecture, ledger architecture, consensus mechanism, transaction mechanism and the four Ps (private, public, permissioned, permissionless). This categorization provides an understanding over the several differences that can characterise the technology in application to port logistics. The blockchain applications are implemented on top of a given platform, being connected through a technical link to a specific blockchain, to provide additional functionalities not initially available. The examples of blockchain applications provided are the smart contracts and the internet of things.

3 Inter-organizational Information system at the Port of Rotterdam

This chapter aims to provide an overview on the port processes drawing an accurate picture of the port environment, the port of Rotterdam was selected a case study. Specifically, this analysis was conducted under the perspective of Portbase, the company that is managing the port interorganizational information system. This chapter opens with a description of the Port Community System (PCS), which represents the current IOIS implemented at the Port of Rotterdam. Second, the import carrier process is described under different perspectives (stakeholder identification, process flows) to provide a general understanding on the practical problem.

3.0 Port Community System

The PCS is a holistic and geographically bounded information system that connects terminal operators, carriers, freight forwarders, ship agents, governmental agencies, port authorities, and various other stakeholders involved in the supply chain. In the Port of Rotterdam, the PCS is governed by a neutral party, Portbase, that receives the cargo information, decompose them based on the content and spread them among the supply chain actors that are involved in the process. Bringing together the diverse parties and keeping records of the transaction led to improve the flow of goods and ameliorate the bottlenecks in the process. The transactional information, which once was moving with the cargo, are now transferred before the cargo arrival through to the intermediary role played by the PCS (Srour et al., 2008).

The interest towards a PCS started over three decades ago with the fast-growth of the worldwide trades. In the 1980s, the port of Rotterdam experienced the blossoming of new companies operating in its ecosystem. One of the major concerns of this network expansion is that companies were strongly dependent on each other, but sometimes they did not have business relations or information exchange with each other. This fragmentation was mainly due to the complexity of the port operations and the inefficient means of communication (phone, fax, postal mails). As a solution, the INTIS (International Transport Information System) project was developed as the first IT platform for EDI message exchange (Park et al., 2005). However, the project failed premature due to organizational, technical and financial reasons. Similarly, the Port CommuniTy Rotterdam (PCR), which was the second attempt of PCS, failed due to the reduced network size. However, the web-based revolution of the 1990s brought new opportunities for the PCS development (Park et al., 2005). The first successful pilot was "W@VE", which consisted in a web-application for road-hauliers to pre-notify their arrival at the terminals (Baalen, 2008) . On the threshold of the new millennium, the urgent demand for a PCS led to the development of the project Port of Rotterdam Main Information Services (PROMISE) (Rodon and Ramis-Pujol, 2006). In 2006, the project was serving a network of 1,000 companies offering 15 different services. In 2009, the network was further expended by the merge with the Amsterdam PCS PortNet, giving birth to Portbase.

3.1 Import Carrier Process

This section aims to present an overview of the import carrier process at the port of Rotterdam. Due to the large size of the process at stake, this research limited the analysis to the port environment, leaving the part of the hinterland transportation for future research. Therefore, this study evaluates the flow of containers from the moment in which the carrier is approaching the port of Rotterdam to the moment in which the goods leave the terminal. The case-study analysis is aimed at identifying the limitations of the current port processes in order to inspect the benefit that a blockchain implementation could produce. To this purpose, this analysis will start with an identification of the main stakeholders. Second the three main process flows (Physical, Financial, Information) will be analysed. Third, the interdependencies and bottlenecks in the process will be identified. The selected case-study is the import carrier process since there are several actors involved and a large amount of documentation required in it.

3.1.1 Process Stakeholders

This section aims to provide a brief description of the stakeholders involved in the import carrier process. It serves as a background analysis for the following sections of process flows analysis. The stakeholders' categorization (Table 1) is adapted from the classification provided by Wagenaar (1992).

Group	Examples of Organization
Customer Group	Consigner, Consignee
Organizing Group	Freight forwarder, Shipping Line Agent, Ship Broker, Logistics Service Provider, 4PL
Physical Group	Sea Terminal Operator, Inland Terminal Operator, Shipping Line, Barge Haulier, Rail Haulier, Truck Haulier, Empty Container Depot Operator, 3PL
Authorizing Group	Customs, Port Authorities, Seaport Police, Inspection Authorities, Rijkswaterstraat
Financial Group	Banks, Insurance companies

Table 3.1: Seaport Stakeholders (Adapted from Wagenaar (1992))

The first category of stakeholders includes the sender (Consigner) and the receiver (Consignee), who represent the customers of the process. Despite we focus on a specific process that take places in the Port of Rotterdam, the sender and receiver hold important roles and have to be taken into consideration even if they are located outside of the port area. The second group includes the logistics service providers, who are in charge of organizing the container transportation along the supply chain. This category is responsible for the transportation planning and control of the supply chain. The third group includes all the organizations that physically handle and/or transport the container along the supply chain. This category is directly responsible for the container and its content. The fourth category is composed by regulatory authorities that monitor the supply chain to respect the laws that apply

on them. Since this group is composed by governmental organizations, they are responsible for the safety and security of the supply chain. Finally, the financial group enables the financial transactions among the trading organizations. Not only they are involved in the financial and information flows, but they have a strong indirect impact on the physical flow.

To prevent misunderstandings, it is necessary to further describe the roles of the parties laying in the “Organizing group”. In particular, we analyse the different roles of three logistics intermediaries that usually coexist in container supply chain:

- **Shipbrokers** are negotiators who connect the ship-owners with the charterers, who use ships to transport cargo. Container brokers are specialized in the organization and management of container ships by providing container ship-owners and charterers with commercial information and opportunities;
- **Shipping Agents** arrange the transport documentation handling, purchase shipping space and sell services to shippers. They manage customs documentation, commercial documentation, necessary certificates. Moreover, they arrange transport modes, transshipment;
- **Freight forwarders** is in charge of arranging the cargo, planning the transport and handling the cargo documentation, specific knowledge of the cargo.

3.1.2 Physical Flow

The physical flow of the import carrier process consists in the physical transportation and handling of goods in containers.

- The process starts with the carrier approaching the port of Rotterdam. Before entering the port, the carrier needs a dock number and an experienced pilot from the port needs to be on board;
- Once the ship is anchored to its quay, the terminal transshipment takes place. According to the carrier size, from three to five large gantry cranes unloads the containers from the carrier. This procedure follows the instructions provided by the stowage plan (Discharge List) since not all containers need to be unloaded and the ship cargo need to be balanced;
- Using Automated Guided Vehicles (AGV) or straddle carriers, every single container is moved to the stacking area. The stacking location is decided according to the container destination; near the sea side in case of barge transportation, on land-side for in-land transportation;
- Once the container is located at the port terminal, it can be selected by customs for inspection, based on the risk analysis. The container selection criteria are confidential and it results in an unexpected selection process, which causes delay or disruptions in the process.
 - o Custom inspection: the container is moved from the container stack to the container scan. At the customs, the container is inspected with an X-Ray technology;
 - o Quality control: Band control, food and consumer product safety control (Veterinary Control);
 - o Gassing/Degassing: While the container is stack at the customs, it can be gassed prior to the inspection to protect its content. During the inspection procedure, the container is de-gassed. This process takes place in a special area of the terminal;
 - o Goods taken into custody: In case some smuggle goods are detected, the related authorities can decide to maintain the goods into custody, while the empty container is moved to the Empty Container Depot (ECD).
- The container release takes place only when the customs duties and freight costs have been payed, the cargo receives the “four green lights”. Once released, the container is ready to be picked by the operator for hinterland transportation. This transportation can occur by barge, truck, or train.
- In the automated terminals, trucks are allowed inside the terminal are only once the four green lights are in place.

- Before leaving the sea terminal, the container loaded on trucks or trains go through a nuclear scan.

3.1.3 Financial Flow and INCO terms

In port logistics, the financial flow has a substantial impact on the physical flow, since a mutual dependency of the two flows characterises some steps of the process. For instance, the physical flow of a container in the terminal area can be stopped and delayed in case the cargo has not been commercially released and the invoices paid. However, it is not possible to generalize the financial flow of the import carrier process in a universally valid description. The characteristics of this flow are dependent on the Incoterms chosen by the transacting parties. The word “Incoterms” is an abbreviation of International commercial terms and they are aimed to facilitate the trader’s life (Ramber, 1999). A trade term is an acronym that encompasses a catalogue of delivery obligations to be performed by either the seller or the buyer (Malfliet, 2011). Using these notations, traders are not required to include extensive agreements regarding trade obligations in their contracts. They simply select one of the predefined incoterms, which specify both the party who is in charge of, and the one who bears the risks during and the costs of transport, insurance, documents and formalities. They are grouped in four categories: E-terms (only EXW): the seller’s set the premises and the cargo is set at the disposal of the buyer (“come to collect the goods”); F-terms: costs and risks relative to the main international carriage are under the buyer responsibility (“goods are sent from”); C-terms: the seller pays the transportation but it does not bear the risks for the international carriage (“goods are sent to, freight prepaid”); D-terms: all costs and risks until the delivery point in the country of destination are hold by the seller (“goods are ‘delivered at”).

In Incoterms, the term ‘delivery’ identifies to the time when cargo responsibility shifts from the seller to the buyer. This shift in responsibility corresponds with transaction of the payment. In case of E-terms, the payment takes place as soon as the cargo leaves the manufacturing company, preventing any process delays due to payment delays. Few process delays take place also in case of F-terms. However, C-terms and D-terms generate considerable delays in arranging the payments due to the shifts of responsibility along the process and the low coordination among the parties.

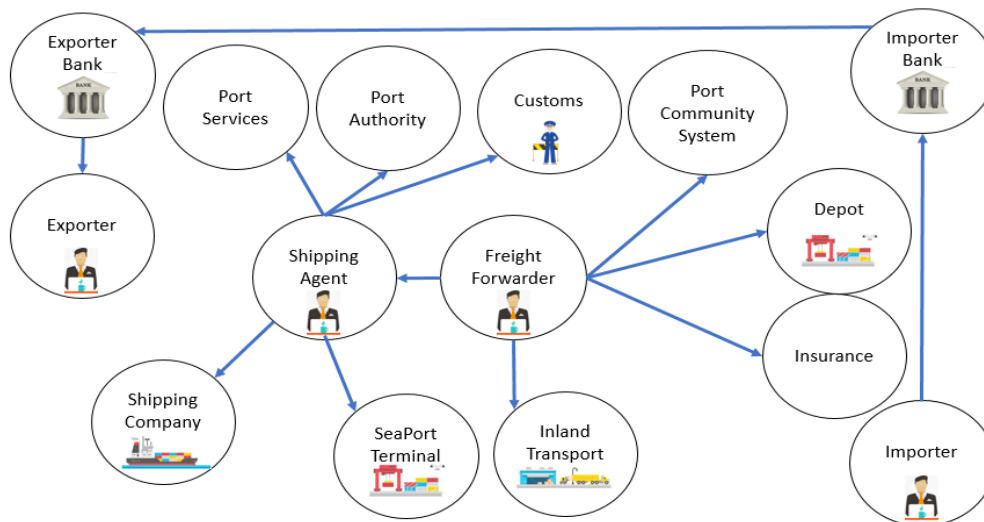


Figure 3.1: Financial Flow (Adapted from Baalen et al. (2009))

3.1.4 Information Flow

This section aims to provide a detailed overview of the documentation system and of the interaction between the stakeholders involved in the process. Evaluating the potential impact of the Blockchain implementation requires an accurate analysis of the current documentary system and exchange of information at the port of Rotterdam. Assessing the number of exchanged documentation and the volume of correspondence within the extended supply chain of the port is crucial to eliminate unnecessary information redundancy. Figure 3.2 provides an illustration of the documentation flow and main interactions among the parties involved in the process. For simplicity, the information flow is divided in three main areas and analyzed as follows:

Container Vessel Approaching and entering the Port of Rotterdam:

- The goods shipment is arranged by freight forwarders, who intermediate between the consigner and the logistics network. Once the freight forwarder has arranged the most suitable chain of transportation, it hires shipping agents to reserve some space on the carrier. Moreover, the shipping agents collect all the cargo-related information and send them to the Port Community System.
- Three days before the carrier approaches the Port of Rotterdam, the ship agent of the shipping line send a Pre-Arrival Notification (Estimated Time of Arrival - ETA) to the Shipping Agent. This information is updated in time while the carrier is approaching the port area.
- The ship agent provides via PCS the “Crew and Passenger Declaration” to Seaport Police, the “Customs Declaration” to the Customs, the “Notification of Dangerous goods” and the “Cargo Manifest” to the Port Authority
- Once the carrier is outside the port, it receives the Call Reference Number, the Berth Number and the Discharge Permit from the Port Authority through the PCS.

Terminal Handling and customs release:

- The cargo unloading procedure is carried out according to the carrier’s Stowage Plan and Discharge Plan.
- According to the risk analysis, the customs may select a container for inspection. This consists in a notification to the PCS, who informs port agent and freight forwarder. Similar procedure is in place for veterinary inspection.
- Once the container is unloaded, or it has passed the customs inspection, a communication is sent to the consignee bank, which sends the payment to the shipping company. The container is not commercially released until the payment has been processed, so it cannot leave the terminal area. Since this communication between the system and the bank does not go through the PCS, it leads to delays in the process.

Hinterland Planning

- Once the cargo has received the so-called “four green-lights” (Cargo unloading, customs documentation control, customs release, and commercial release), it can continue its journey towards the hinterland.
- The ship agent, shipping line or freight forwarder, depending on the different case, get in contact with the hinterland transportation to arrange the shipment. The selected mean of transportation receives the PIN for container release, which is a code that links the transportation mode to the cargo.
- Once the cargo is stopped at the customs or it is delayed by other procedural controls, it can happen that the container is held at the terminal until the hinterland transportation is arranged. In this case, the cargo’s owner may face costs of detention and demurrage.

Figure 3.2 and Table 3.2 provide a visualization of the process information flow. As follows, some findings and guidelines to interpret the chart are provided:

Table 3.2: List of documentation used in the container import carrier process

1	Bill of Lading (B/L)	13	Harbor Dues
2	Letter of Credit (L/C)	14	Vessel Clearance
3	Letter of Credit Request	15	Customs Declaration
4	Insurance Request	16	Customs Clearance and Inspection
5	Transportation Info and Updates	17	PIN for container release
6	Estimated Time of Arrival (ETA)	18	TAR code
7	Estimated Time of Departure (ETD)	19	List of Crew and Passenger
8	Manifest	20	Discharge List
9	Call Reference Number	21	Stowage List
10	Berth Number	22	Discharge Updates
11	Notification of Waste Disposal	23	NDG
12	Notification of Dangerous goods	24	Cargo Information

- The process described takes place mainly in the port environment. However, to draw a complete picture of the actors playing key roles in the process, some actors from the loading port and the hinterland area were also included in the analysis. Some of the actors that play an important role in the process, such as banks, are not included in the network of the PCS. This leads to delays in communicating information with parties outside the platform.
- The use of different colors to draw the communication lines among the actors showed that the PCS does not manage the complete information flow of the process. The only communications relative to the process operations are exchanged through the PCS (red lines). All the other communications (blue lines) are exchanged through bilateral connections.
- Many actors in the process require the same information or documentation (i.e. Bill of Lading, Manifest, ETA, Declaration of Dangerous Goods). Moreover, some of them may include some addendums to the original documentations, which represent updates of the original documentation. However, these addendums are not easily redistributed to the actors in the process.

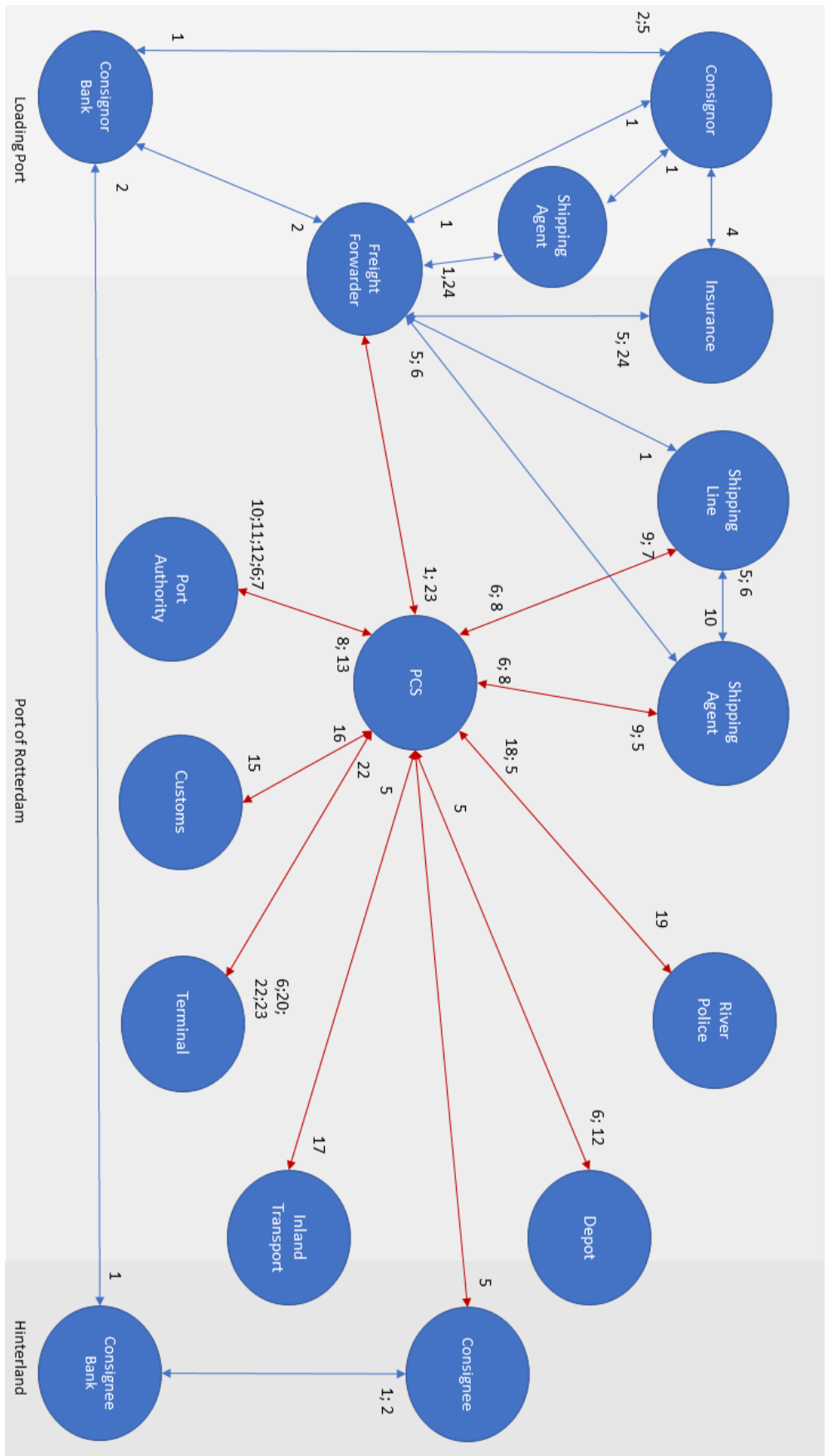


Figure 3.2: Information Flow of the Import Carrier Process

3.2 Flows Interdependencies

Currently, there are several interdependencies among the three different flows, which cause coordination challenges in port logistics. For instance, the lack of certain information when needed may cause delays or disruptions in the physical flows. This can happen when certain documentation is inaccurate or when different organizations manage contrasting information on the same good. Moreover, the container release (Physical flow) takes place when it is “commercially released”, which means that the shipping line has paid the freight transport. However, the financial flow can be equally hindered by the physical flow when information about the process are not promptly communicated. Similarly, the container is released (physical flow) when the authorizing parties (Customs, Veterinary, Immigration Office) have been performed their operations. This controls might be lowered in terms of volume by providing a detailed and reliable flow of information about the cargo. These represent only few examples of coordination issues, which lead to a slower and less efficient process. The role of IOIS is to create coordination among the three different flows working as an information hub.

3.2.1 Process Bottlenecks

The coordination among the actors involved in the intermodal transport of containers is cumbersome and it generates several process bottlenecks. One of the main reasons behind this issue resides in the reluctance of some organizations to share process data and increase the operations visibility. In a competitive environment, companies may be hesitant in sharing information that could decrease their competitive advantage over similar organizations. Other reasons behind the lack of coordination consist in the interdependencies among different supply chain flows. Delays generate when the communication among parties outside and inside the physical flow does not occur timely. However, not all the process bottlenecks derive from a lack of coordination in the process. For instance, the customs clearance represents a process step that generates uncertainty in the process and prevent other parties to generate accurate planning.

In this section, some major information issues and bottlenecks of the import carrier process are evaluated. The issues described are relative to the import carrier process, which appears to be characterized by a larger amount of uncertainty due to the several actors involved and the procedure for container release from the deep-sea terminal. Moreover, the issues identified do not represent the only bottlenecks in the process, but they aim to provide a clear evidence of the uncertainty in the process.

3.2.2 Container Reshuffling

The term “call size” identifies the quantity of containers unloaded from the vessel at the terminal. Generally, the magnitude of the call size is measured in thousands, but the increase in size of the container vessel has boosted the volumes. To insure a short ship turnaround time, the containers unloaded from the vessel are temporarily stored in stacks. These

intermediary storage work as buffers to position unloaded containers before the transshipment or other hinterland connections.

Currently, the containers are stacked one on top of the others almost without a predefined order. The terminal does not have a complete picture of the priorities that the singular container has to move towards the hinterland. Once the planning for the hinterland transportation is communicated to the terminal, the containers have already been unloaded and they are stacked randomly. The result consists in several handling movements to retrieve a container that is piled below others with a lower priority. This is defined as the reshuffling phenomenon and it increases in magnitude with the height of the stacks. To decrease this information uncertainty, terminal have adopted forecasting algorithms (Tang et al., 2015; Ting and Wu, 2017). However, these forecasting attempts are not accurate since some parameters are not clear at an early stage of the process. For instance, the mode of transportation towards the hinterland is decided by the freight forwarder once the container is unloaded. Nevertheless, the container's priority information is known by the freight forwarder and it would help in solving the reshuffling issue if communicated to the terminal.

3.2.3 Container Clearance

One of the key process uncertainties is represented by the container release time, which determines when the container can be picked up at the terminal. The container cannot leave to the hinterland until the cargo's invoices have been paid and the customs have performed their inspections. This uncertainty implies a domino effect on the planning of the transportation mode, which is not scheduled until the container clearance has been received.

The customs release is dependent on the accuracy of the cargo documentation and on the risk analysis. On the one hand, the container is stopped in case the documentation is inaccurate or not in place. On the other hand, the flow is delayed by a possible check of the contents of the container with X-ray technology. This clearance is physically and administratively time consuming. Increasing the consistency and the accuracy of the documentation would lead to better risk analysis and lower customers control required.

The commercial release takes place when the invoices linked to the container are paid. For instance, the terminal operator will clear the container when the handling fee has been paid. However, the financial transactions are processed by parties outside of the physical process such as banks and financial institutes, which are not connected to the PCS. Therefore, these parties have not visibility on the process steps and they receive updates from the freight forwarders. This time for information receipt is summed to the time to process the payment and send the payment guarantee back to the process. This is an example of lack in coordination among the parties in the process that are performing sequential operations. Moreover, it represents an example of interdependencies between the physical, information, and financial flows.

3.2.4 Hinterland Transportation Arrangement

Once the container has received the commercial and customs clearance, the terminal generates a PIN, which is transmitted to the freight forwarder and used to enter the terminal for the pickup retrieval. However, due to the uncertainty of the previous process steps, the hinterland transportation is usually arranged only once the container is released. This implies a longer process lead-time, which increases the chance to incur in costs for demurrage and detention.

Information regarding the release time of the container should be shared with intermodal operators as soon as updates on the clearance operations are available. For instance, the bank should receive the information on the payment before the due time. It is also helpful to provide timely alert messages that announce an anticipated delay, e.g., in the case when the container gets blocked for further inspection by customs. A better planning of intermodal transportation can be developed by sharing the planning of the terminal activities, bank payment process and customs control process.

3.3 Findings from the case study

Chapter 3 provides an in-depth understanding of the port processes, describing the import carrier process at the port of Rotterdam. The data are retrieved from the Portbase's point of view, which ensures a clear and unbiased picture of the information flow. To evaluate the room for improvements at a process level provided by a blockchain solution, the physical, financial and information flow are mapped. Since the three process flows show a large amount of interdependencies, the new information technology is expected to provide improvements at the information flow level, which has a positive impact on the other two flows. Some of the process areas that blockchain is expected to improve are container reshuffling, the customs release, the financial release, and the hinterland transportation arrangement. Based on these findings, the following chapters will introduce a set of blockchain business cases to port logistics, as well as a list of port performance indicators to test their impact on the process flows.

4. Business-cases for blockchain in application to port logistics

This chapter introduces the building blocks for a KPIs analysis aimed to evaluate the impact of four blockchain use-cases on port performance. The proposed analysis introduces key port performance indicators (KPIs) as a tool to assess the technology implementation. The identification of port KPIs is rooted in the current literature. Since there is not a clear understanding on the future implementation of the technology, four business cases of blockchain implementation will be described and evaluated. The process of business case's identification starts from the analysis of the current market applications. Second, technology functionalities will be evaluated and grouped into four business cases. The business case's analysis through the KPIs is the result of a set of interviews conducted to people who are part of the major group of port stakeholders working at the port of Rotterdam.

4.0 Methodology to derive port process KPIs

This analysis is a first attempt to describe the impact of Blockchain business cases on port processes. My purpose with this study is evaluate the areas related to port processes where the disruptive technology has a major impact. To this end, port specific KPIs are defined and business cases' performances have been evaluated.

The process of KPIs generation was structured in three steps. First, scientific papers related to the topics were collected from various sources (ScienceDirect, Scopus, Google Scholar). This literature inspection process started with a simple research on the search engines of the key-words: "Port KPIs", "Inter-Organizational System KPIs", and "Port Processes KPIs". Second, the KPIs found on the literature were categorized and assessed in terms of match with the analysis objective. Finally, a complete list of KPIs was developed to describe the port processes in a comprehensive and organized manner.

On the basis of the literature background information, the process of KPIs selection was based on the following assumptions: 1) The selected indicators aim to depict a full image of the port processes; 2) The indicators take the point of view of the multiple process stakeholders, who are the potential users of the blockchain technology; 3) The selected indicators are aimed to evaluate process's support technologies.

The selected KPIs represent a framework to evaluate Blockchain business cases in terms of impact on port processes. Due to the lack of data on the process, this analysis has a qualitative nature and the impact is measured on a three-values grading scale. Therefore, the magnitude of the impact is defined by using three colours: red for "high-impact", yellow for "medium-impact", no colour for "no-impact".

The business case's impact analysis is the result of a round of interviews to different blockchain experts working in the port environment. The people participating to the interviews were appropriately selected not only for their knowledge on Blockchain technology, but also for the organization they are working in. This second requirement, in particular, drove the selection of candidates towards a varied sample of respondents with the aim to grasp the point of views of the main process stakeholders. During the interviews, the respondents were requested to attribute a value to the different KPIs per each business case. Each interview started with a description of the Blockchain business cases, their functionalities and their practical uses. Second, the respondents are asked to analyse every business case according to the provided KPIs. Third, some exploratory questions are addressed to the respondents in order to better identify their roles in the process and the interdependencies among them. The interviews resulting values are displayed on Appendix A.

4.1 Port Process Performance Indicators

4.1.1 Port KPIs Literature Review

Performance management is a key strategic activity for port communities to evaluate the port performance at both inter-port and intra-port levels. In this research, the use of KPIs is meant to compare the current port's IOIS with a Blockchain implementation in terms of port operations efficiency and efficacy. Therefore, this study focuses the performance evaluation at an intra-port level.

Despite the broad literature on port performance measurement, there is no standard method that is applicable to every port. As stated by Esmer (2008), this difficulty is compounded by the fact that there is no a single measure that can sum up the multifaceted port environment. Traditionally, ports have assessed their performance through an engineering approach, by comparing the actual against the maximum port throughput rate and the number of container handled. Similarly, a large amount of literature focused on the use of KPIs in container terminal under the assumption that port performance strongly depends on the efficiency in handling cargo (Bendall and Stent, 1997; Tabernacle, 1995; Ashar, 1997; Talley, 2006; Esmer, 2008). In 1976, UNCTAD (United Nation Conference on Trade and Development) defined two categories of KPIs: macro performance indicators quantifying the port impacts on the economic activity; and micro performance indicators appraising the port operations. This first classification, has been established as the reference point for guiding research ever since (UNCTAD, 1976).

In recent years, significant progress has been made concerning the port performance appraisal. A significant addition to the field was the work of Antao et al. (2005), who noticed that port performance should not be confined to quantitative analyses, but qualitative indicators may depict a more precise image of the port. In this vein, Marlow and Pixao Casaca (2003) introduced the logistics concepts of "lean" and "agile" operations as a main factor of port performance. Based on this concept, they suggested a set of indicators to assess the leanness in port environment and along the entire supply chain. Bichou and Gray (2008) proposed the adoption of a logistic approach to port performance measurement structured in three categories of indicators: physical indicators, productivity indicators, economic and financial indicators.

A significant contribution to the field was brought by Tsamboulas et al. (2012), who built an evaluation framework to appraise the introduction of PCS. The authors identify some KPIs for port authorities and major process stakeholders to evaluate the financial, operational and functional indicators on logistic processes. This research represents the reference point of our analysis since it provides a valuable list of performance indicators to measure the port inter-organizational system. Moreover, it compares the implementation of PCS with the previous port communication system. Finally, it analyses the stakeholder's perspective on the technology by evaluating to which extent a PCS generates an added value its customers.

4.1.2 Port KPIs selection

As documented in section 4.1, numerous indicators have been proposed in the literature to evaluate port performance. Based on this background, a set of KPIs are identified to evaluate the expected benefit provided by blockchain technology to port logistics. The selected KPIs are grouped on three categories according to the three process flows: financial, operational, and informational. Table 4.1 lists the KPIs selected with their relative description.

	Name	Description
Financial	Freight bill Accuracy	Estimation of the number of errors in freight billing, which include incorrect pricing, incorrect or unavailable information, etc. Calculated by dividing the number of error-free freight bills by the total number of freight bills over the period (Tsambouls et al., 2012).
	Overall Cost for the Information flow of a unit of cargo from the first to the last nodal point	It measures the IOIS performance in terms of information flow total cost. It provides an estimation of the impact of costs relative to the port information flows with respect to supply chain cost. It is calculated by summing the price paid by the different stakeholders in transacting cargo information.
	Average cost for detention/demurrage	The amount of container's demurrage or detention in the port in terms of costs. These phenomena are the proof of delays in payments or paperwork unavailability and errors. It is measured by dividing the total cost for container's demurrage or detention by the total number of container.

Operational	Ship Turnaround time	The total time spent by the vessel in port, during a given call. It is the sum of waiting time, plus berthing time, plus service time (i.e. ship's time at berth), plus sailing delay. Ideally, ship turnaround should be only marginally longer than ship's time at berth and thus waiting time in particular should be as near to zero as possible (Marlow and Pixao Casa, 2003).
	Road vehicle turnaround time	The total time required to collect a container from the terminal or deliver one. For shippers/receivers (and trucking companies), it is the most important measure of a terminal's efficiency. It is the average time spent by the road vehicle, from the moment when it enters the port to the moment when it leaves the port (Esmer, 2008).
	Time spent by cargo awaiting commercial viability	The time from the communication regarding the cargo unloading at the terminal to the bank, until the proof of commercial viability release. It is a measure of the commercial viability impact on the physical process in terms of process delay.
	Time for goods to be cleared	The average time for goods to receive the customs' green light in case the customs' check are required. It is a measure of the customs control's impact on the physical process in terms of process delay (Marlow and Pixao Casa, 2003).
	Time spent by cargo awaiting departure of next mode of transport (road or rail)	The average time for cargo awaiting at the terminal after it has received the four green lights. It shows the ease to arrange a transportation mode (Tsambouls et al., 2012).
	Overall time of cargo in port	The total time spent by the cargo in port. It is the sum of waiting time, custom and commercial clearance, plus process delay (Marlow and Pixao Casa, 2003).
	Ship's capacity utilization	The percentage of cargo's available capacity that is being used on the carrier. It

		defines the efficiency in ship's utilization (adapted from Tsambouls et al., 2012).
	Hinterland transportation modes' capacity utilization	It measures the percentage of hinterland transportation's available capacity that is being used. It defines the efficiency in transport's utilization (adapted from Tsambouls et al., 2012).
Information	Security in information sharing	It measures the security of the mean of communication, in terms of information access and information sharing. (Marlow and Pixao Casa, 2003).
	Degree of Flexibility in using information technology	The degree of flexibility in shaping the information sharing according to the desired standards of communication. It is a measure of the information technology adaptability. It is measured by estimating the number of communications that do not flow through the IOIS (Marlow and Pixao Casa, 2003).
	Access speed to information	The speed in receiving or accessing the information needed at the right time in the process. Not only it is a measure of the information timing but also information availability (Tsambouls et al., 2012).
	Accuracy of information regarding status of shipment	It measures whether the parties involved in the process have access to correct and accurate information on the shipment. It can be measured by counting for all (Tsambouls et al., 2012).
	Provision of on-time updates of cargo information	The availability of updated information on the cargo. It is evaluated by counting for the average cargo awaiting time for lacking information (Tsambouls et al., 2012).
	Time required to receive necessary process information	The time for the IOIS to receive updated information regarding the process steps. It evaluates how reactive is the system in generating and sharing updated information. It can be measured by (Tsambouls et al., 2012).

Table 3.1: Selected KPIs with relative description

4.2 Business cases of blockchain applications to port logistics

The objective of this section is to evaluate the main functionalities brought by the technology to the field of supply chain and logistics. The logistics market is currently characterised by a low and contradictory understanding on the uses of the technology. Moreover, the literature does not provide any categorization of the potential uses of blockchain in logistics. The approach taken in this research project starts with a description and categorization of the current blockchain's market applications in the field of logistics. The analysis of the functionalities offered by these applications represents the starting point for the business cases development. Therefore, this study is an initial practical attempt to categorize the potential blockchain use-cases in the logistic field. The analysis starts with a description of the methodology used and a evaluation of the main limitations. After this premise, the current market application are listed and a set of functionalities extracted. Finally, these functionalities are grouped into four business cases of Blockchain implementations, which represent the starting point for the business cases-KPIs analysis.

4.2.1 Methodology and Limitations

The evaluation of the functionalities offered by the current blockchain applications was structured in three steps. First the current Blockchain applications were collected from various sources (Crunchbase, Github, Dapps) and search engines. Second, a set of information was retrieved for each application from the company's and other websites to understand the proposed use of the technology. Third, these applications were listed and described (Appendix B). Fourth, a categorization based on the value provided by the different applications was proposed.

The market solutions described in this section consist in applications and not blockchain fabrics (Glaser, 2017). While the fabric provides the infrastructure for multiple applications to be developed upon; the applications is the act of putting a platform to a special use or purpose. Therefore, the analysis of applications allows the evaluation of the different values propositions achievable with blockchain applications.

Despite several blockchain applications might have a potential if applied to supply chain, this study took into consideration the only applications that specifically mentioned on their website that they applied in the field of logistics. Moreover, it is possible that some existing applications are not included on the study, due to their novelty or low visibility on the internet. However, this section aims to use the current applications as the starting point for business cases building. Therefore, we believe that the applications evaluated can already provide a valuable sample to derive some conclusion on the spectrum of functionalities brought by Blockchain to the field of study.

4.2.2 Applications Functionalities

Table 4.2 and Table 4.3 provide a list of Blockchain current market applications. The key functionalities proposed are evaluated for each of the market applications.

By analysing the website’s description of each application, it was possible to understand and classify the different uses of the technology. This analysis was performed by identifying the key-words included in each description, such as “bill-of-lading digitalization”, “Letter of credit substitution”, “Smart Contracts”, “Internet-of-Things”, “Trade Finance”, and others.

Market Application	Functionalities Provided
Blockfreight	-Bill of Lading and Documentation transaction -Letter of Credit -Smart Contract Automatization
Blockverify	-Product Traceability
Cargochain	-Bill of Lading and Documentation transaction
Chain of Things	-Process Automatization -IoT enabler
Chroma Way	-Process Automatization through Smart Contract
Consentio	-Trade Finance
Fluent	-Trade Finance
Gatechain	-Bill of Lading and Documentation transaction -Trade Finance -Smart Contract Automatization
Mendix	-IoT Automatization
Open Trade Docs	-Bill of Lading and Documentation transaction
Provenance	-Product Traceability
Skuchain	-Trade Finance -Bill of Lading and Documentation transaction
SolasVGM	-Cargo Information transaction
Smartcontract	-Smart Contract Automatization
TallySticks	-Trade Finance
Wave	-Bill of Lading and Documentation transaction

Table4.2: Blockchain market applications and functionalities provided

Once every application was associated to one or few specific technological functionalities, we defined the main blockchain business cases for port logistics and we list the applications that refer to each of them, as shown in Table 4.3.

Cargo Documentation Transaction	Process Traceability	Trade Finance	IoT and Smart Contract Automatization
<ul style="list-style-type: none"> • BlockFreight • CargoChain • Gatechain • OpenTradeDocs • Skuchain • SolasVGM • Wave 	<ul style="list-style-type: none"> • BlockVerify • Provenance 	<ul style="list-style-type: none"> • Blockfreight • Consentio • Fluent • Gatechain • Skuchain • Tallysticks 	<ul style="list-style-type: none"> • Blockfreight • Chain of Things • Gatechain • Mendix • SmartContract

Table 4.3: Blockchain market application grouped per functionality

4.3 Business cases Building

4.3.1 Cargo Documentation Transaction

4.3.1.1 Business case's *environment and problem statement*

Port logistics is a complex environment where physical movements and information flows are bounded together and managed by a large number of stakeholders. The transportation of goods from the sea-vessel to the hinterland does not only consider the physical movement of the containers, but information related to the shipment also flows along the supply chain. This information flow is acknowledged to be equally important as the physical flow since it enables stakeholders to efficiently perform their tasks (Pruksasri et al., 2014). By tradition, the cargo-related information is in form of documentations (i.e. Bill of Lading, Manifest, Notification of dangerous goods, Discharge List, and others). However, despite the growing digitalization, most of these documentations still flow in paper copies (Takahashi, 2016; Pruksasri et al., 2016). Furthermore, in case of mismatch between the information on the documentation hard-copy and the reality, the issue is solved with bilateral means of communications (Phone calls, emails), which are not efficient in a network perspective. This inefficient cargo information sharing leads to information asymmetries, where every company creates its own cargo-related information. Updated information on the cargo are currently not always shared, but stored in the company's ERP, which acts as information silos not accessible by all the companies in the process. This situation can be enlarged by taking the whole supply chain as a unit of analysis, instead of the port reality.

4.3.1.2 Blockchain functionality

To solve this cargo information deficiency, blockchain technology raised the interest of both academia and industry for the technology essential feature of "guarantee of uniqueness". This guarantee enables the creation of a unique documentation that does not change throughout its life-cycle, so that the holder of the document can exercise the right to claim the performance of the obligation (Takahashi, 2016). This capability gives to Blockchain technology an advantage over the past attempts of freight documentation's digitalization. As described by Takahashi (2016), since 1986 the digitalization of documentations such as Bill-of-Lading was realised by closed and member-only central registries. These attempts were administered by a central and trusted intermediary, but they have never reached a critical mass of users to be established as a market standard. On the other hand, Blockchain can work as a built-on-trust information system which ensures the "guarantee of uniqueness".

4.3.1.3 Business case's boundaries

This Blockchain business case consists in using the technology to store and transact the cargo-related information. Many of the market applications that offer this functionality aim to create a global ledger that is accessed by parties scattered all over the world. However, since the scope of this analysis is to evaluate the blockchain impact on port logistics, we will have a local perspective confined to the port environment.

4.3.1.4 Business case's description

Traditionally, the cargo-related documentation was passed from one to another actor who are part of the supply chain. This procedure was shifted with the implementation of the Port Community System, which represent a central-hub that collect and redirect all the information. A blockchain application would radically change the data sharing scheme, moving from data-passing (data push) to data-requesting (data pull). This new configuration implies that the cargo-related information is recorded on the chain by the information owner (the shipping agent, freight forwarder or shipping line in port logistics). This represents an insurance of information accuracy since there are no intermediaries between the information owner and the information user. Once the cargo-information is included onto the ledger, the parties that take part in the cargo physical flow get access to it. This business case of implementation leads to decrease the risk of documentation fraud, reducing errors in documentation and most importantly increasing the speed of the overall document transfer process. Unlike the paper copy or the electronic copy (PDF), the documentation stored in the blockchain requires the approval of all the stakeholders and possible changes can be detected easily.

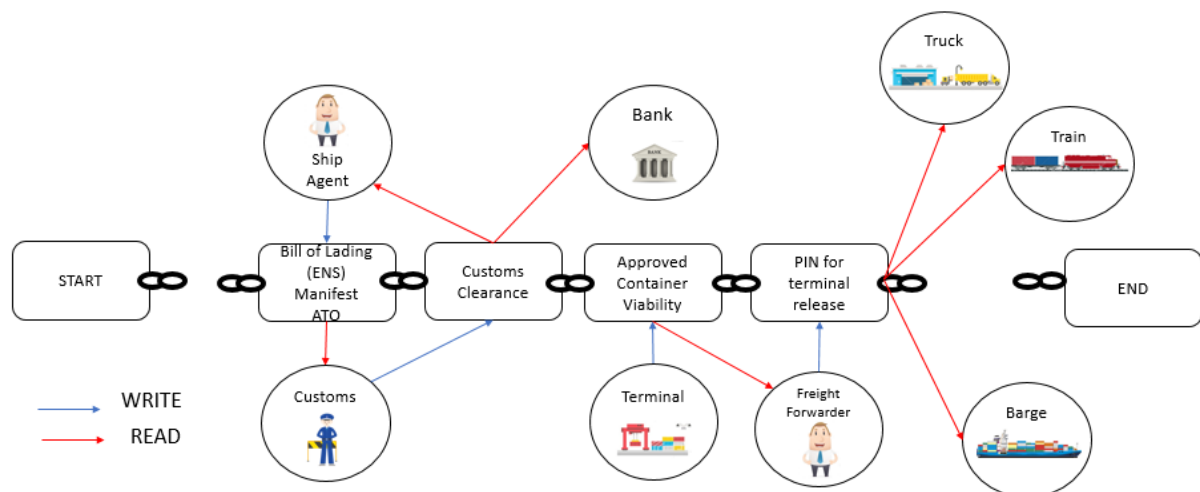


Figure 4.1: Example of blockchain application for cargo documentation storing

The market applications that aim to store and transact cargo documentation through blockchain mainly focus their attention on the Bill of lading. The Bill of Lading (B/L) is a document that includes information about the shipment and, more specifically, about the goods being transferred, including their quantities and their destination (Morabito, 2017). The main market applications that market this blockchain functionality are Blockfreight, Cargochain, OpenTrade Docs, Skuchain, and Wave. However, there are other market

applications that provide the same functionality to store and transact via blockchain other information relative to the cargo, such as SolasVGM. This U.S. based application aims to provide a unique and accurate measure of cargo's Verified Gross Mass to the different parties in the supply chain. Similarly, other sorts of cargo documentation might be recorded on blockchain application, such as the Manifest, the Notification of Waste Disposal, the Notification of Dangerous Goods, the List of Crew and Passenger, the Discharge list, and others.

4.3.2 Process Traceability

4.3.2.1 Business case's *environment and problem statement*

From the sea-vessel to the hinterland location, the container is handled by many stakeholders and it goes through several process steps. This complex ecosystem does not provide real-time information to keep external parties updated on the container's process development. In port logistics, it is usually very difficult to have an overall picture of all transactions within the process (Haq et al., 2010). This information is typically stored in multiple locations and it is limited in accessibility. This lack in process visibility hinders the coordination among the different process stakeholders, which ultimately results in increasing the process total time. Furthermore, the lack in visibility hampers the process bottlenecks to be identified and solved at an early stage.

4.3.2.2 Blockchain functionality

To solve this lack in visibility, blockchain technology can be used as an immutable ledger to store process timestamps. When a new process step is performed (i.e. container unloaded from the vessel, container has left the terminal) the system automatically records the time of completed action (process timestamp). This allows the network to create an immutable and chronological order of entries related to a specific product (i.e. container). In comparison to the current technologies, blockchain can provide some key technological advantages that are implications of its structural architecture. Some of these features are: 1) Transparency – each node in the network maintains a blockchain copy that can be audited and inspected in real time; 2) Immutability – The traceability of data stored is practically immutable due to the need of validation by the other nodes in the network.

4.3.2.3 Business case's *boundaries*

Many of the market applications that offer this functionality aim to apply the concept of traceability on a global scale, with the objective to trace the product's provenance. In this perspective, the blockchain is used to evaluate when and where a certain product is originated, manufactured and used throughout its life cycle. However, this blockchain use is out of the scope of this research since it does not have a strong impact on port logistics. On the other hand, the use of the functionality to record and transfer process timestamps may have a strong impact on port operations to increase process coordination and eliminate bottlenecks.

4.3.2.4 business case's description

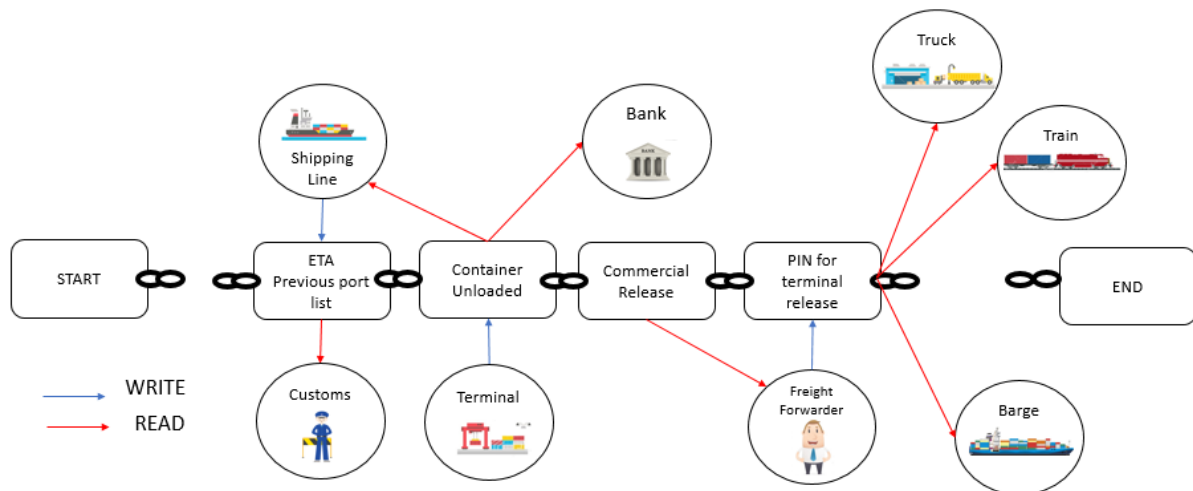


Figure 4.2: Example of blockchain application for process information storing

The proposed functionality comprises of a decentralized distributed system to collect, store and manage key process information regarding each product throughout its process development. This creates a secure and shared record of the process steps for each product. Since the process of product movement comprises a variety of actors (i.e. terminal operators, customs, shipping agents, freight forwarders, hinterland transportations, shipping line), this functionality allows a better coordination and a real-time access to process-related information. Each product (container) would be linked to a virtual identity on the network. Similarly, the process actors would also have a digital identity that will be used to sign the timestamp authenticity.

4.3.3 Trade Finance

4.3.3.1 Business case's environment and problem statement

Trade financing is known to be characterized by large inefficiencies and high chances of frauds (Skinner, 2016). For instance, the U.S. market accounted for losses that reached 0.5 billion US dollars in 1995 due to trade finance frauds (Brunes and Byrne, 1996). Similarly, the Commercial Crime Bureau recorded a loss of 2.4 billion Hong Kong dollars (around 0.3 billion US dollars) in 1998 (Zhang, 2011). One of the most common and standardised forms of bank-intermediated trade finance is a letter of credit (L/C), which is used for financing the international trade. This document has been at the centre of several fraudulent attacks in last decades. The UNCTAD report provides a classification of four kinds of popular L/C frauds: 1) when the cargo is non-existent, the documents are falsified by the beneficiary in order to obtain

payment from the bank; 2) where the goods are of inferior quality or quantity; 3) where the same goods are sold to two or more parties; 4) where bills of lading are issued twice for the same goods (UNCTAD,2003). In order to prevent these fraud attempts to occur, banks require a long time to process and validate the financial transactions. This time expansion has a direct consequence on the port operations, causing delays in the process. In particular, containers are hold in the terminal until they do not receive the proof of commercial viability by the commercial bank. Moreover, since banks are usually not included in the Port Community System, they do not receive real-time notifications on the status of the container. This lack of coordination slows down the process causing an increase in transportation costs and detention costs.

4.3.3.2 Blockchain functionalities

Blockchain is a built-in-trust technology that might contribute to trade finance by guarding against frauds and saving reconciliation costs. Combining the fraud prevention with the advantages brought by an inclusion of banks into the blockchain network, leads to a smoother process flow and a short process total time. Therefore, the main blockchain functionalities in place are the trust on the system, the “guarantee of uniqueness”, and the network effects.

4.3.3.3 Business case’s *boundaries*

Many of the market applications that offer this functionality aim to improve the worldwide trade finance substituting the commercial banks with the technology working as a proof of trust. However, the effects of this technology use can be seen on a global scale. In port logistics, the effects of trade finance on process optimization are more relevant. Therefore, this business case will mainly evaluate the effects brought by: 1) the integration of banks in to the port network, which consists in faster communications 2) the integration of the L/C on the blockchain to speed up the process of container commercial viability.

4.3.3.4 Business case’s *description*

The proposed functionality comprises of a decentralized distributed system to store trade financing document (L/C) onto the blockchain and include banks into the port’s IOIS. Once the vessel is berthed and the containers are unloaded at the terminal, an on-time communication is sent to the consigner bank, which is part of the port’s IOIS. Subsequently, the bank check the consignee’s solvability and send the confirmation of container’s commercial viability. This process, as it is currently performed, can lead up to two days of process delays.

4.3.4 IoT and Smart Contract Automatization

4.3.4.1 Business case's *environment and problem statement*

IoT mainly consists of embedding sensing and communication capabilities to a wide range of physical objects and connecting these devices to each other over the internet so that they can monitor their environment, communicate their status, and even take actions based on the information they receive. Therefore, the implementation of Internet of Things and Smart Contracts in port Logistics may have a large potential in terms of process automatization. Of the estimated €16,8 trillion value at stake in IoT over the next decade, roughly one tenth of that value is attributed to IoT in transportation and logistics (Bradley, Reberger and Dixit, 2017). Smart devices in logistics can have a large amount of applications: sensors monitoring the use of assets (e.g. trucks, cranes, carriers, roads, etc.) and infrastructure (e.g. roads, parking lots, warehouse storage rooms, etc.) to identify underused capacity and, subsequently, optimizing it by relocating assets or rerouting goods flows; smart storage systems with temperature, humidity, and ventilation sensing ability to detect the needs of the cargo could increase product quality and decrease cargo damage.

However, this business case of implementation is still relative abstract according to the current state of things. On the one hand, the port's environment is still characterized by a limited use of smart devices, which are not connected and the information generated are not shared among the parties in the network. On the other hand, smart contracts is a broadly debated concept due to the risks related to their implementation and use in reality. Done of the main issues of IoT and Smart contracts represents the free flow of data that these systems communicate to a central platform that coordinates the aggregation, analysis, and interchange of this data. Many competing firms in the port environment are often hesitant to share information with a central authority that will aggregate this information with that of competitors. Therefore, blockchain technology represents a secure data management system that only shares relevant data with the concerning parties through an encrypted approach, backed up by confidentiality agreements.

4.3.4.2 Blockchain functionalities

In application to smart contracts and smart devices, blockchain is valuable due to its nature as a scalable, trustless peer-to-peer technology that can operate transparently and securely in the distribution of data. In other words, it solves the problem of data security with respect to the information generated by the smart devices.

4.3.4.3 Business case's *boundaries*

Many practitioners are still sceptical about the broad use of these blockchain solutions. Smart contracts are criticized since it is not always easy to express business logics as computer programmes, as well as executing every program for every message on every blockchain node (Greenspan, 2015). However, this research does not aim to solve purely technical issues, but it focuses on the benefit offered by the business case. Therefore, it identifies smart

contracts and smart devices as solutions able to automatize the process by reducing non value-added activities and communications.

4.3.4.4 Business case's description

The use of IoT and Smart Contract leads to a full process automation in terms of physical, financial and information flows. By installing trackers or smart devices on the containers, the goods' conditions and locations can be directly registered on the blockchain. These signed transactions are sent to the blockchain automatically without any user input, and the process timestamps can be recorded directly on the ledger. Moreover, combining the data generated by the smart devices with smart contract enables the system to automatize low value added operations. For instance, once the container is unloaded, the smart devices register the event on the ledger, which communicate the information automatically to the bank to start the procedure of commercial viability. Similarly, the smart devices are able to evaluate whether the container's internal condition has changed as a result of legitimate container's opening. This information can be communicated to the port's customs and it can be used to enhance the trade's security.

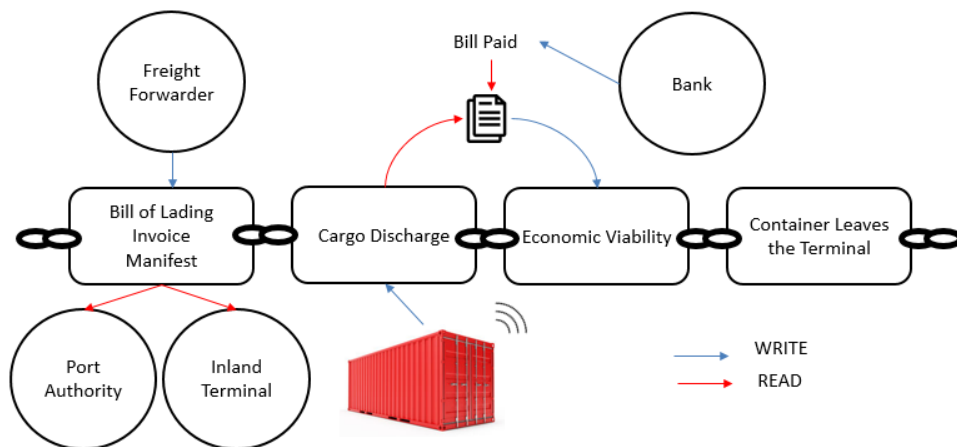


Figure 4.3: Example of blockchain application using IoT and Smart Contracts

4.4 Business cases-KPIs Analysis

The KPIs selection and the business cases building are aimed to build a table for the evaluation of the blockchain impact on port logistics. The table combining the two axis under analysis is presented in Table 4.4. It consists in the table that has been filled by the respondents during the round of interviews.

KPI		Cargo Documentation Transaction	Process Traceability	Trade Finance	IoT and Smart Contract Automatization
Financial	Freight bill Accuracy				
	Overall Cost for the Information flow of a unit of cargo from the first to the last nodal point				
	Average cost for detention/demurrage				
Operational	Ship Turnaround time				
	Road vehicle turnaround time				
	Time spent by cargo awaiting commercial viability				
	Time for goods to be cleared				
	Time spent by cargo awaiting departure of next mode of transport (road or rail)				
	Overall time of cargo in port				
	Ship's capacity utilization				
	Hinterland transportation modes' capacity utilization				
Information	Security in information sharing				
	Degree of Flexibility in using information technology				
	Access speed to information				
	Accuracy of information regarding status of shipment				
	Provision of on-time updates of cargo information				
	Time required to receive necessary process information				

Table4.4: business case's impact on Port KPIs

5. Business cases evaluation and results description

This section aims to provide an analysis of the blockchain business cases based on the interviews to the main actors from import carrier process. Two types of analysis will be performed. First, the port KPIs will be analyzed singularly in order to evaluate the features of the three process streams (physical, financial, Information) on which the technology can have a positive impact. This first perspective does not take the into consideration the technology categorization in business cases, but it aims at describing the key blockchain features that have a positive expected impact on port logistics. Second, an analysis per business cases will be performed to evaluate the expected benefits provided by each use of the technology on port logistics. This study enables the evaluation of the different business cases to identify which of them is expected to generate a positive impact on port logistics. Third, a final discussion on the results will be executed.

5.0 Methodology

This section aims to provide a methodological background to the interviewing process and result analysis. Since the interviewed people represent the source of information, we will start by describing the respondents profile. Second, the criteria for respondents' selection will be provided. Third, the selection process will be described to explain the steps followed to research information. Fourth, the interviewing process will be described to prove the methodology validity and the study replicability. Fifth, the result analysis process will be defined to clarify the path that led to the development of the main findings. Finally, the main methodology limitations will be identified.

5.0.1 Interviewee profile

On average, the people interviewed have more than ten years of experience in the field of logistics and they have a technical educational background, which provides them with the tools to interpret the technology and its main building blocks. Moreover, they have a clear understanding on the port processes both on the operational and information perspectives. Despite these main guidelines for describing the respondent's profiles, the people interviewed play slightly different roles in the companies where they work (innovation consultant, intermodal delivery manager, business architect, policy advisor, digital services developer). However, these people are considered the advocates for the development of blockchain solutions in the business environment where they operate. This turn them into optimal candidates for the evaluation of the different blockchain business cases.

5.0.2 Criteria for selection

The sample of respondents was accurately chosen based on two main criteria of selection:

- The people interviewed have previous insights on the blockchain technology. Some of the respondents were selected since they are already exploring blockchain solutions in applications to port logistics. Others were selected because of their interest on the topic and their regular participation in conferences around topics such as blockchain and smart logistics.
- The sample is selected to include the all main actors in port logistics. In particular, the ones that play a significant role in managing the process information flow. Therefore, the group of respondents were selected from shipping lines, ship agents, freight forwarders, port community systems, terminals, and customs. Selecting players with different roles in the process ensured the inspection of the process from multiple perspectives and depict a complete overview of it.

5.0.3 Selection Process

The first source to identify potential respondents was participating to the smart logistics sessions organized by Smart Port. These conferences are focused on the identification of innovative solutions based on blockchain technology. The researcher was put in contact with the people who are at the front-end of blockchain research in application to port logistics. As a result of these meetings, the potential candidates were listed and contacted by email in order to arrange individual meetings of approximately one hour and half each.

5.0.4 Limitations

The reduced sample size (six interviews) is the result of several factors:

- Since blockchain is a relatively new technology, there is still a general lack of knowledge on its benefits and limitations. Therefore, the availability of people with insights on the blockchain phenomenon is restricted to a narrow group of innovators.
- Due to limitations of time and geographical distance, the people interviewed were confined to the Rotterdam area.
- The interviewees were selected to provide the point of views of the different categories of stakeholders playing a role in the process. However, it was difficult to find several people for each category. In order not to create a disequilibrium among the categories, the choice to have one respondent per category was taken.

Since the respondents are selected from different stakeholder categories, they do not hold the same knowledge on the different steps of the import carrier process. For instance, the respondent working at the customs has a deeper understanding over the customs requirements on a blockchain solution. Similarly, other respondents provided more insights about the areas of the process where they regularly perform their activities. The selection of a sample of respondents composed by people with different knowledge can represent both a

limitation and an advantage. On the one hand, it is a limitation since cross-case analysis does not provide with interesting insights since the respondents do not have the same knowledge over the same KPI. On the other hand, it is an advantage since the analysis offer an almost complete picture of the process, which is not bias by the specific interest of a certain category of stakeholders over the technology.

5.0.5 Interviewing Methodology

This analysis was performed making use of a semi-structured interviewing technique. This choice enabled the interviews to be open-ended and maintain a conversational style while closely following a study protocol. The interview protocol was designed in a way that the questions are framed in an unbiased manner. As suggested by Yin (2009, pag. 110), “how” questions were preferred over “why” questions to prevent defensiveness behaviors on the interviewee side. Moreover, the questions were framed to avoid the presence of the interviewer’s perspective in the question. This prevented any mutual and subtle influence of the interviewer on the interviewee’s answer.

Audiotapes of the interviews were preferred to personal notes. Transcriptions of the recordings are provided in Appendix A. To counterprove the researcher interpretation over the discussed topic, an email with a summary of the performed interview was sent to each respondent.

The interview procedure was composed of three main parts. First, some open-ended and exploratory questions were asked. The purpose of these questions was the identification of inefficiencies in terms of information flow in the different process steps. Second, the respondent where asked to evaluate the impact of the business cases on the different KPIs comparing the current situation with the benefits and limitation brought by the blockchain solutions. Every time that the respondent evaluated a potential impact of the business case, she was asked to provide some reasoning behind the choice. Third, some questions behind the major impacts of the business cases were addresses. Example of this concluding part of the interview are: “what do you think are the reasons behind the lack of process information sharing in the process?”. The interviews lasted a minimum of one hour to a maximum of one and half hour. On average, the impact of the different parts on the total time was 20% for the first part, 60% for the second and 20% for the third part.

5.0.6 Interview analysis

The analysis of the interviews in this thesis is set up to be inductive. Therefore, there are not much pre-conceived expectations or hypothesis to be tested previous to the data analysis. This approach is justified by the main objective of the analysis, which consists in the inspection of the unknown impact of the blockchain business cases on the three flows of the port processes. The semi-structured nature of the interviews is chosen to specifically allow participants to expand upon the questions providing insights that could not be achieved deductively.

The interviews analysis started with the evaluation of the KPIs tables filled by the respondents. First, the values provided by the different interviewees are compared to evaluate whether there

is unanimous consent over certain impacts. Second, each business case is analysed individually. Third, a conclusive discussion is provided.

5.0.7 Interviews Results

This section aims to provide an analysis of the blockchain business cases based on the interviews to the main actors from import carrier process. Two types of analysis will be performed. First, the port KPIs will be analyzed singularly in order to evaluate the features of the three process streams (physical, financial, Information) on which the technology can have a positive impact. This first perspective does not take into consideration the technology categorization in business cases, but it aims at describing the key blockchain features that have a positive expected impact on port logistics. Second, an analysis per business cases will be performed to evaluate the expected benefits provided by each use of the technology on port logistics. This study enables the evaluation of the different business cases to identify which of them is expected to generate a positive impact on port logistics. Third, a final discussion on the results will be executed.

5.1 Analysis per KPI

5.1.1 Financial Flow

The respondents forecast the blockchain business cases to decrease the cost for information transaction for all the stakeholders interviewed. In particular, the interviewees unanimously identified a cost reduction in transacting process information among the stakeholders. This type of information is currently transacted among the parties using P2P means of communications, which generate redundancy in case the single event has to be communicated to more than one party. By storing the information on the ledger and providing the different parties with the access to them, it leads to a reduction in transaction costs of the excessive number of transactions. Since this type of information is not currently shared among the different parties, the large benefit provided by blockchain does not only consist in decreasing the cost for information transaction, but being able to canalize the process information to the system.

As described in chapter 3, financial and physical flows are characterized by interdependencies, which lead to delays due to the lack of coordination among the parties

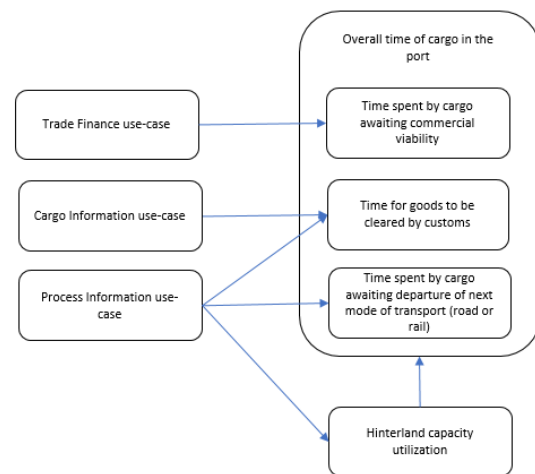


Figure 5.1: Impact visualization of blockchain business cases on the port KPIs based on the interviews

operating the two streams. By improving the on-time communication among the two flows the payments have a lower chance to be delayed. This implies healthier financial conditions of the creditors as well as stronger relationships among the transacting parties.

5.1.2 Physical Flow

This section aims to evaluate the role that the technology plays in speeding up the process and increasing the port throughput rate. The respondents unanimously evaluated the blockchain having the potential to decrease the total time spent by cargo in the terminal. This can result from the partial or complete elimination of three main sources of delays: the customs clearance, the commercial clearance, and the planning of the hinterland transportation. Among others, these three process steps derive from a lack of integration and coordination between physical and information flows.

Figure 1 provides a visualization of the impact that the different blockchain business cases are expected to have on the physical flow port KPIs. The stakeholders identified the trade finance business cases having a positive impact on the time spent by cargo waiting for commercial clearance. Using blockchain to store cargo information is likely to decrease the time required for the customs clearance. Similarly, storing process information on the blockchain might contribute in decreasing the time required for customs clearance and the hinterland transportation planning.

5.1.2.1 Customs Clearance Process

The customs clearance has been evaluated by many respondents as a source of uncertainty which prevented the parties from developing accurate planning. However, this uncertainty is intrinsic to the process since cargo inspection is kept secret for reasons of public security. For instance, the contraband of drugs takes place at the terminal where sometimes the smuggler is able to unload the illicit substances hidden in the container before it is checked by customs. If customs provide more information about the checks planning with the objective of decreasing the uncertainty, smugglers may have an advantage by getting hold of this data. Despite this uncertainty cannot be eliminated, customs operations can perform better risk analysis which improve the chances of stopping drug smuggling. In turn, this would lower the volume of containers checked, decrease the number of false positives and, ultimately, speed up the process. To this purpose, customs require more reliable, accurate and precise information.

The respondents evaluated the first blockchain business case as a potential solution for increasing the cargo information accuracy. Having the cargo documentation stored in the blockchain since an early stage of the supply chain would prevent the information to be lost or manipulated insuring information consistency. This would decrease the chances that different parties in the process hold contrasting information about the content of the same container. This type of solution is already being developed by a EU founded consortia working in the so-called "COREproject". The impact of this solution can be explained by analysing the impressive volume of today's paper-based documentation used in ocean trade. Maersk conducted a study to map the "200 different and often paper-based communication interactions between 30 individuals or organisations involved in the transport of goods from

East Africa to Europe. This mapping showed that the cost of time spent on documentation processes is equal to the actual shipment costs.”(Skjoldborg, 2015)

However, the consistency about the cargo information is not sufficient to ensure a better risk analysis. The cargo documentation only provides information on what the container is “said to contain”. Therefore, the origin and the destination of the container as well as its transportation information represent relevant data towards the improve of the customs process. For instance, by evaluating the ports visited by the vessel before the arrival in Rotterdam it is already possible to have an idea of the risk level tied with the container. In case the vessel has visited a port of discharge which is not characterized by a high level of security, the authorities could decide to stop the flow to perform more accurate controls. Storing this type of information on a blockchain solution and increasing the customs visibility of the container transportation history can contribute in performing more accurate risk analysis. The immutability feature of the ledger can ensure the information reliability and trustworthiness. Moreover, sharing this information through a blockchain solution would increase the control over the data accessibility preserving some commercial information to be reachable by competing firms.

5.1.2.2 Commercial Clearance Process

The process of commercial clearance is dependent on the type of transportation and responsibility are in place. Delays in the process of commercial clearance usually take place when the INCO terms chosen for the container transport imply a change in responsibility at the port of discharge. In these cases, the invoice payment can be performed only when the container is unloaded at the terminal. However, the unloading process step is communicated to the bank with some delay, which sums up to the time required for the bank to perform the payment resulting in an excessive delay in the total process. The interviewees identified blockchain as a solution that can improve the bank visibility over the process steps in order to increase the coordination. Moreover, connecting the bank with the stakeholders operating on the physical flow could canalize the communication between actors in and out of the physical process to the blockchain.

This network expansion requires a standardization of the operations. In turns, a company’s efforts to standardize the processes generates network externalities and it opens the way for other companies to standardize its processes accordingly. This may result in a further network expansion.

5.1.2.3 Hinterland Transportation Planning

Once the terminal has received the customs and commercial clearances, it is allowed to leave the terminal. However, due to the variability of the two process steps already described, the transportation planner cannot make an accurate planning beforehand on the hinterland transportation in terms of time and mode. Moreover, even when the green-light is received, the container is held at the terminal since the transportation mode is arranged in time. The interviewees identified the blockchain business case of process information storage as beneficial to decrease the time of the cargo waiting for the hinterland transportation arrangement. An increase in process information availability would provide a better visibility over the process steps. This would increase the coordination among the actors, who can be informed on-time on process updates and promptly arrange the hinterland transportation. The

increase in visibility does not only mean to inform the freight forwarder and the hinterland transportation about the green light receipt, but also the terminal about the hinterland mode of transportation selected

5.1.3 Information Flow

The information is evaluated based on its accuracy, consistency, timeliness, security, and ease of accessibility. The blockchain business cases at stake differentiate based on the type of information they aim to store and transact. Each type of information requires the technology to be structured in a way to enable specific attributes embodied in the information. For instance, cargo information is characterized by a lack of accuracy in the current situation. Therefore, implementing a blockchain solution that follows the whole supply chain provides a larger impact than a narrower technology specific for the port environment. Process information is not easily accessible in the current situation. This requires the technology developers to develop a solution that fosters the different stakeholders to collaborate.

5.1.3.1 Accuracy

The interviewees identify accuracy as a fundamental attribute of a blockchain technology that is designed to store cargo information. By uploading the cargo information at an early stage of the process, the developer can prevent the data from being modified and conflicting information on the same container to emerge. The accuracy of the data is not to be inspected all along the process but at the source. This implies that, if the source of information is trusted, the information itself is trustworthy.

Accuracy of the process information corresponds with the timeliness of information. Since the process information consists of informing other parties that a process milestone has been performed, the accuracy of this information resides in its timeliness rather than in the content itself. Therefore, in the second and third blockchain business cases the information accuracy does not represent a fundamental requirement of the technology.

5.1.3.2 Consistency

Information consistency represents one of the intrinsic features built on blockchain. Since the technology consists of an almost immutable ledger, the information stored on it is tamper-proof. Therefore, the information holds the same over time. This represents a fundamental feature for the first blockchain business case, which requires the information to be free from manipulations. This technological capability was identified by almost all the respondents as a required feature for the technology development.

5.1.3.3 Timeliness

Since the cargo documentation is already transacted to the Dutch customs at least twenty-four hours before the vessel departure, the timeliness is not an issue for the first blockchain business case. However, it represents a required characteristic for the second and third business cases, which aim to inform the parties in the system about the process development. Several respondents identified the importance of this specific feature to improve the coordination and the on-time visibility over the process development.

Despite some consensus mechanisms on which current blockchain solutions are built are not meant to provide real-time solutions, new technological solutions will provide a faster blockchain recording (i.e. the TU Delft developed TrustChain). However, deciding to implement Proof-of-stake solutions other than Proof-of-work solutions would already decrease the time required for recording an information on the ledger, since the latter requires a shorter time for solving the computation problems behind the encryption mechanism.

5.1.3.4 Ease of Accessibility

The information system (PCS) operating in the port implies the information to be transacted to the orchestrator party, who subsequently redistribute it to the parties who need it to perform their operations. The blockchain solutions sees the information stored on the chained and accessed by the different parties when needed or when they get access to them. The respondents identified a moderate improvement brought by blockchain compared to the current situation. However, the impact is considered by most of the interviewees not so relevant to be listed among the beneficial impacts provided by the technology.

5.1.3.5 Security

Blockchain is seen by many respondents as a secure and trustworthy technology due to the encrypted technology which it is built upon. Some respondents identified how building the information system on a trustworthy technology might incentivize some parties in sharing a larger amount of data. In fact, there is not the chance that the data are transacted to a party that may use that in an unfair way, unless the player providing with the access to the information allows it. Despite many respondents identified security as a major impact provided by all four blockchain business cases, the technology is not completely secure. If the private key that enables a user to get access to the information on the ledger is lost or stolen, external parties have visibility on the information of behalf of the frauded user.

5.2 Analysis per Business Case

This section is aimed at performing an analysis per business case in order to evaluate the interviews responses and identifying the impact of each business case on the port environment in terms of financial, physical and information flows.

5.2.1 First Business Case of Implementation – Cargo Information Transaction

	TOT			KPI	
				Description	
Financial	1	1	-	1) Freight Bill Accuracy - Making use of data available on the blockchain to develop invoice	
	3	2	1	2) Overall Cost for the Information flow of a unit of cargo from the first to the last nodal point - Shifting from “Data Push” to “Data Pull” decreases the working time to store and share info. - Digitalization of cargo documentation. Elimination of paper copy.	
	1	1	-	3) Average Cost for Detention and Demurrage - Reliability and accuracy in cargo documentation leads to faster customs control processes, which faster process lead-time and less chance of detention and demurrage.	
Physical	1	1	-	4) Ship Turnaround time - Accurate not. of crew and dangerous goods can decrease time for inspections and speed up the process	
	1	1	-	5) Road vehicle turnaround time - Avoiding that the hinterland transportation enters the terminal and the documentation is not in place	
	1	1	-	6) Time spent by cargo awaiting commercial clearance - Elimination of delays for lack of cargo documentation provided to third parties.	
	6	3	3	7) Time required for customs cleared - Higher accuracy and consistency of information, less chance of manipulation. More accurate risk analysis leads to less false positives, less inspections, a faster process. - No chance for freight forwarder and ATO to have contrasting info., which block the container at customs. - Accuracy ensured by initial information owner, who is responsible for info provided.	
	2	2	-	8) Time spent by cargo awaiting departure of next mode of transport (road or rail) - If the documentations are not in place or in order, the container cannot leave to the hinterland	
	5	4	1	9) Overall time of cargo in port - The results of KPI 6 + KPI 7 + KPI 8	
	1	1	-	10) Ship's capacity utilization - It has more influence in the export process than in the import process	
	0	-	-	11) Hinterland transportation modes' capacity utilization	
	Information	6	2	4	12) Security in information sharing - The encrypted mechanism ensures cargo info. from being altered and accessed by non-authorized parties. - Cargo information is sometimes shared via email, which can be easily hacked. - The storage of cargo information has to be regulated to prevent commercial information spill over and opportunistic behaviours.
		1	-	1	13) Degree of Flexibility in using information technology - Storing the cargo information and addendums on the chain leads to a faster process in information query, which decreases the P2P communications.
		5	5	-	14) Access speed to information

			- If the cargo documentation is already stored on the ledger, the access speed to info is faster. Access to information is given by querying the system instead of asking to another party.
6	4	2	15) Accuracy of information regarding status of shipment - Reduced number of parties handling the info., decreases the chance of manipulation and increases accuracy - The information owner is the one that records the info., less intermediaries involved and more consistency in place
4	4	-	16) Provision of on-time updates of cargo information - The technology has not just-in-time recording, but once recorded, it is just in time reading. the access to information is given simultaneously to many parties instead of transacting information to each of them. - Network expansion can increase the availability of info and number of parties informed.

5.2.2 Second Business Case of Implementation - Traceability

	TOT		KPI
			Description
Financial	1	-	1) Freight Bill Accuracy
			In transportation billing storage days, detention and demurrage and other process info are involved. Higher visibility over process information can be a source of billing information.
	5	5	-
			2) Overall Cost for the Information flow of a unit of cargo from the first to the last nodal point - Lower number of P2P communications to share process updates. Shift from "Data Push" to "Data Pull" decreases the working time to store and share info. - Transport companies have several interfaces with ISs to retrieve process info, low integration. - Recording of process steps to trace back the causes behind a mistake that took place. - Removal of information asymmetries which increase the cost of information transaction.
4	2	2	3) Average Cost for Detention and Demurrage - Process visibility might increase the coordination among actors, which decreases the process total time and the chance for detention and demurrage costs.
Physical	1	1	-
			4) Ship Turnaround time
	2	1	1
			5) Road vehicle turnaround time - A better coordination among actors based on increased information exchange leads to new way of planning. For instance, terminal could better stack and retrieve container decreasing road vehicle turnaround time. Coordination helps in preventing and solving disruptions.
	0	-	-
			6) Time spent by cargo awaiting commercial clearance
6	4	2	7) Time for goods to be cleared - Process Information is an extra-source of information in the process of customs clearance for better risk analysis to have less false positives, less inspections, a faster process. - Communication to customs of information that is already present in the process but not presented in a structured way. -While cargo information is non-accurate since it refers to "said-to-contain" information. Trends can be derived from process information to detect smuggling parties.
5	4	1	8) Time spent by cargo awaiting departure of next mode of transport (road or rail) - Process information sharing leads to increase the coordination among parties and kick start to new form of planning. This decreases the time for the arrangement of the hinterland transportation. For instance, the terminal need info about the mode and time of transportation and the hinterland transport needs info. For a better operations planning
			9) Overall time of cargo in port

	6	4	2	- A process visibility has the potential to improve customs clearance process, commercial clearance process and hinterland transportation planning, impacting the process total time.
	0	-	-	10) Ship's capacity utilization
	4	2	2	11) Hinterland transportation modes' capacity utilization - Lack of process information generates delays in the process. This slows down the following steps in the process, making barges or trains leaving without a fully-exploited capacity
Information	5	5	-	12) Security in information sharing - Confidential process information sometimes is transacted via email enabling smugglers to interfere in the import process. - The access to the process information is provided to the only parties that require the information to perform their tasks
	4	4	-	13) Degree of Flexibility in using information technology - Decrease of P2P communications enabling process visibility to more parties and process traceability
	4	3	1	14) Access speed to information - Information stored on the ledger is easily retrievable compared to the process of asking to another party in the process for the information access.
	2	2	-	15) Accuracy of information regarding status of shipment
	5	5	-	16) Provision of on-time updates of cargo information - Info uploaded by the parties that generate them, not by intermediaries, on-time availability and on-time accessibility of process updates - Process info that are currently stored in someone's database is shared to authorized parties

5.2.3 Third Business case of Implementation – Trade Finance

	TOT			KPI
				Description
Financial	3	3	-	1) Freight Bill Accuracy
	2	2	-	2) Overall Cost for the Information flow of a unit of cargo from the first to the last nodal point Simplify communication between parties inside and outside of the physical flow in terms of number of P2P transaction and time for transaction.
	3	1	2	3) Average Cost for Detention and Demurrage The lack of coordination among the parties inside the port process and the financial institutions outside it leads to delays in communication, which increase the process lead-time and the chance for detention and demurrage.
Physical	0	-	-	4) Ship Turnaround time
	0	-	-	5) Road vehicle turnaround time
	6	4	2	6) Time spent by cargo awaiting commercial clearance - Higher visibility of parties outside the process over the physical flow. Elimination of communication redundancy. It automatizes and simplify the process of commercial release. - It solves the problem of communication that occurs when there is a change in the responsibility over the cargo.
	0	-	-	7) Time for goods to be cleared Customs might double-prove cargo information with external parties, such as banks and insurances, to perform a better analysis and have extra-proof of cargo value for taxation.

	1	1	-	8) Time spent by cargo awaiting departure of next mode of transport (road or rail) - Including external parties in physical flow, increases the level of process uncertainty leading to a better planning capacity. Ultimately, this can speed up the arrangement of the hinterland transportation.
	4	3	1	9) Overall time of cargo in port Decreasing the time required for commercial release and communication to parties outside of the physical flow, the process can be speeded up.
	1	1	-	10) Ship's capacity utilization An easier letter of credit procedure could impact the starting up of cargo. This latter improvement is not really related to the cargo side of process, but improving the trade finance could enable more companies to organize their supply chain and fill the empty capacity.
	0	-	-	11) Hinterland transportation modes' capacity utilization
Information	3	1	2	12) Security in information sharing Storing documentation such as the L/C on the ledger enables the information to hold immutable and consistent all over the chain. Trust mechanism might be substituted by a blockchain solution.
	2	2	-	13) Degree of Flexibility in using information technology Increase in flexibility due to the inclusion of parties outside of the process and the reduction of P2P communication.
	2	2	-	14) Access speed to information
	1	1	-	15) Accuracy of information regarding status of shipment The accuracy of the information necessary for trade finance is sometimes lacking, since the invoices include a value that is sometimes different from the value shown on the cargo documentation.
	2	2	-	16) Provision of on-time updates of cargo information On-time process updates to parties who are external to the process. In the current situation, these updates slow.

5.2.4 Forth Business case – Automatization through IoT and Smart Contracts

The first three business cases (Cargo Information Transaction, Process Information Transaction, and Trade Finance) can be compared among each other since they imply the use of the technology to store and transact a certain kind of information but they are different based on the type of information used. On the contrary, the fourth business case represent a distinct use of the technology compared to the first three use cases. The companies commercializing functionalities belonging to the fourth business case aim to automatize transactions making use of data already stored on the chain. Five respondents out of six identified this difference among the first three business cases, defined as “short-term use cases” and the fourth one, which represent a “long-term use case”.

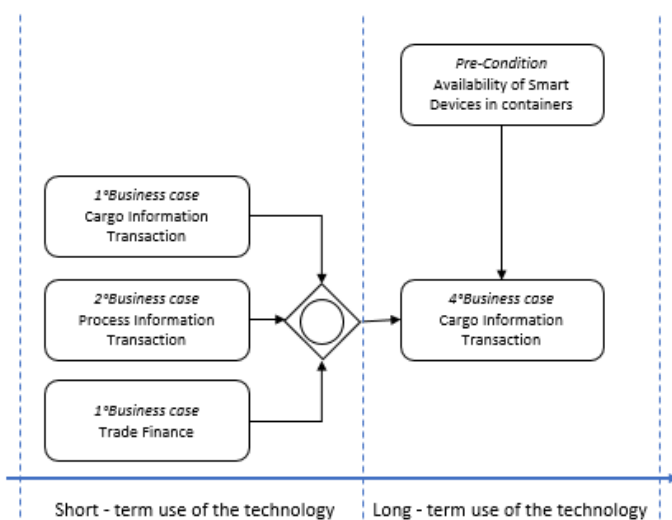


Figure 5.2: Business cases subdivision based on priority level

Moreover, to develop the fourth business case of blockchain application, it is necessary to have at least one of the “short-term use cases” working as a source of information. Smart Contracts represent an automatization of the transactions, while Smart Devices represents an automatized mechanism to retrieve information and, in this case, write them on the ledger.

Despite the different level of analysis required by this business case, every respondent acknowledged the potential of smart devices and smart contract as tools to create a more automatized process. This perspective is in line with the trend of automatization, which McGinnis et al. (1994) identified as the most recurring trend in logistics. In particular, this business case has potential to improve many of the process steps, such as commercial release, customs release, hinterland transportation and terminal handling.

More than 80% of the respondents expect that smart devices have the potential to inform external parties (banks, insurance) about the status of the container can speed up process steps using smart contracts. Almost half of the interviewees evaluated this business case has having a strong impact on the process total time. Similarly, smart devices could provide an enlarged set of information to customs in order to perform better risk case analysis. Finally, by establishing smart contracts and setting deadlines for the hinterland transportation, non-added value activities can be automatized.

5.3 Examples of Business Collaboration enabled by blockchain

5.3.1 Redistribution of costs in truck platooning

A blockchain solution could keep track of the platoon position that road vehicles have when queueing for being loaded at the terminal (who leads the platoon, who is at the back, who joined halfway, etc.). By recording these data for a period of time, hinterland transportation can arrange cost settlements (for the redistribution of the fuel consumption) via a blockchain solution. Moreover, by establishing an internal virtual currency, the different hinterland companies can exchange virtual credit to arrange evenly the differences in consumption. By implementing smart contracts, it is possible to automatically arrange which truck drives at the front and the back next time. This is all to distribute the fuel savings fairly.

5.3.2 Priority on containers leaving the terminal

Since the freight forwarders have an overview on the container’s priority in leaving the terminal, they could store this information on the chain to enable the terminal in performing better stacking operations. Once these data are written on the ledger, they are read by the terminal software in charge of prioritizing the containers during the discharge operations. This can result in a better stacking, which avoid the problem of knowing the container pickup time.

5.3.3 Blockchain traceability

The main objective of this research project was the evaluation of the blockchain potential in the field of port logistics. This focus on the port environment, rather than on the whole supply chain led to the interpretation of the concept “traceability” under a purely operational perspective. Therefore, all along the research “traceability” was meant as a capability of the technology to record an increase volume of data about the port process, with the aim to increase the process visibility. This approach is justified by the project’s target, which consist of the company working in the logistic industry. However, shifting the target of the research project, it is possible to attribute different definition to the concept of “traceability”. On the one end of the supply chain, end-user identifies “traceability” as the blockchain ability to trace the time and place on which certain products are manufactured, used and transacted through their entire life-cycle. On the other end of the supply chain, organizations involved in circular economy identify “traceability” as a tool enabling new social contracts for sustainability. This section aims to analyse the concept of “traceability” according to the perspective of these two categories of actors in the supply chain.

In today’s globalised market place, goods often travel along a broad network of retailers, distributors, transporters, warehouses, manufacturers and suppliers before reaching the end customer (McDonald, 2007). In many cases, the final customer has no visibility over the long journey of the product she purchases. Since supply chains are becoming increasingly complex and global, customers are progressively demanding for transparency as a matter of risk prevention and environmental concerns regarding the products purchased. This gave the raise to the birth of several quality certifications (Fairtrade, Organic), which aim to provide a better understanding over the product supply chain (Ponte and Gibbon, 2005). These recognitions, however, are merely logos printed on the product packaging that are not verifiable by the end-customers.

Blockchain has the potential to establish transparency in the supply chain by recording the several transactions that take place in the product’s journey. Being a decentralized system, the technology does not need any central organization performing as an information broker. The absence of central orchestrator prevents the existence of a single point of failure which owns a significant power due to the possession of valuable data. Moreover, the encryption mechanism built behind the technology decreases the chance for malicious attacks (hacking) (Abeyratne and Monfared, 2016).

Applications of blockchain technology for the traceability of products are already in place. For instance, Everledger attempts to use blockchain (Hyperledger platform) to trace the origin of diamonds. It consists of a 3D digital map of the gems which is recorded on the ledger and used to prove the authenticity. Additionally, certificates of authenticity are stored and transacted via the encrypted technology.

5.4 Conclusion on blockchain and Business Collaboration

The implementation of the PCS as the port IOIS aimed at maximising competitiveness and profitability for the single companies, the port ecosystem and the supply chain as a whole,

including the end-customer (Lambert et al., 1998, p. 4). A number of studies promoted the benefits of this collaborative approach (Aksentijević et al., 2009; Aydogdu and Aksoy, 2015; Carlan and Vanelslander, 2016). Some of the claimed benefits include: increased efficiency, increased quality of information, reduced cost of information, less illegal transaction, efficient use of resources (Carlan and Vanelslander, 2016).

Despite these initial expectations around the use of the PCS to increase the coordination in the port environment. The set of interviews presented on Appendix A identified that there is still a long way to go in the path towards process visibility. As identified in the interview with the shipping line: “the lack of trust and the scarce information sharing represent some big challenges for port coordination. People do not trust each other and are not willing to share information that might affect the company's competitiveness. Despite the market is expanding, the profit margins are really limited.” Similar perspectives on the problem were provided by the ship agent and the freight forwarder, proving that the lack of trust among the different parties in the process is a common belief. These perspectives rose doubts about the implementation of a new technology as a solution for process coordination.

At an abstract level, the benefits of a blockchain implementation in the port environment are generally clear to all parties. However, at the concrete organization level these advantages are not so evident since some parties may even benefit from lack of transparency. Network leadership, in particular, is considered to be one of the main barriers to overcome in the adoption of information systems in the supply chains (Van Baalen et al., 2009). The technology aims to unlock these network leaderships and enable the parties in the port environment to establish new collaborations. It generates collaboration opportunities for parties that have never collaborated before and it improves the information flow among parties who already have business relationships. However, many companies show reluctance in engaging in new business partnerships since their competitive advantage over the network might be eroded. Moreover, reinforcing partnership might arise some companies' fear to become too dependent on the other party (Iacovou et al., 1995). This threats mainly arise among the SMEs enterprises, but are also perceived by some large corporations. Moreover, the lack of trust and the lack of a long-term vision over the collaboration advantages represents a fundamental barrier in adopting the technology.

6. Portbase's business model: the past, the present, and the future

6.0 Introduction

As it often happens with breakthrough technologies, Blockchain is currently surrounded by a substantial hype and uncertainty about its use cases. This business case leads to an overestimation of the technology benefits as well as an underestimation of the time required to unfold the technology. In other words, architectural changes in how value is created and appropriated within a specific company do not happen overnight, especially in blockchain where the entire port ecosystem needs to adapt to successfully implement the technology (Michelman, 2017). Compared to other realities in the logistic sector, the Port of Rotterdam has not faced large resistance towards blockchain implementation from regulators or incumbents. However, the uncertainties regarding the technology use cases represents one of the major hurdles for companies to adopt the technology. This blurred future development of the technology prevents organizations to strategically adapt their business model towards a blockchain implementation.

The aim of this chapter is to provide a complete analysis of the Portbase's current business model in order to evaluate its robustness vis-à-vis the fast and unclear change in digital technology. Moreover, this analysis aims to identify a set of business model solutions that Portbase could adopt in response to each of the technology's business cases. This objective addresses the uncertainty that the company's strategists have on the technology's use cases and on the future actions regarding a potential blockchain implementation. Therefore, this research aims to evaluate the impact of blockchain technology from a business model perspective.

This analysis starts with an investigation of the current literature on business model innovation and business model tools. Second, the CANVAS model will be described in detail since it represents the key tool for the Portbase's business model analysis. Third, the company's business model will be described and the results of the workshop at Portbase will be presented. Fourth, recommendations to Portbase on the business models to adopt in response to a blockchain solution will be provided.

6.1 Methodology

This analysis revolves around the identifications of critical effects of blockchain onto the business model components, which is the purpose of the stress test exercise. To test the viability of a business model, this study makes use of the stress testing tool. This methodology involves testing the impact of stress factors on the various business model components. However, before being able to test the viability of a business model, the company's business model requires an in-deep analysis as well as success factors need to be identified. This has been achieved by hosting a focus group, in which a brainstorm session on these elements was held. Combining the practical knowledge of the members in the focus group, with the

knowledge from the literature review and desk research, it has yielded the potential impact that stress factors have on Portbase's business model.

During the stress test, the participants have argued for a certain contribution of the success factors on each business model component, this has yielded a heatmap. The argumentation behind this heatmap provides the input for the analysis of the success factors. This argumentation has been tape-recorded and it can be seen as a form of transcription.

The stress test has been carried out in a workshop session with a group of people familiar with Portbase's BM and Blockchain technology (de Reuver, 2017). This group session is facilitated by an external domain expert, who guides the discussion, extracts the results and aims to avoid biased conclusions or tunnel-vision. The meeting was set up to develop an explorative evaluation of the company's BM. The group session is audio-registered. The group members' selection was based on the individual preparation on the topic and the role covered in the organization. The selected people are involved in the decisions regarding the company's future strategy. Therefore, they are the most suited for evaluating future scenarios and the company potential reaction.

6.2 Business Model Innovation – Literature Review

Business model (BM) and business model innovation (BMI) are increasingly gaining the attention in the academic literature as well as in practice. There is already a consistent literature on BM and BMI that ranges from conceptualizations, to ontologies, typologies and taxonomies. Despite this growing interest on the topic, many researchers provide different definitions of BMs (Morris et al., 2005). This research is built on the definition stated by Bouwman et al. (2008), who define BMs as "a description of how an organization or network of organizations intends to create and capture value with its products and services". To understand how firms can create value and generate profit, technology plays a key role.

The interaction between technology and business models has been described by many scholars. This relationship can be summarised in a two-way manner. On the one side Chesbrough and Rasmussen (2002) sees the resources, such as technology, as inputs that are converted by the company in products or services to realize economic value (Chesbrough and Rosenbloom, 2002). Therefore, the inherent value of a technology is latent until it is commercialized. On the other hand, de Haaker et al. (2017) see new technologies as a change in the business environment that require companies to adapt their BMs. In this second perspective, new technologies are just one of the environmental forces that affect the company's BM. Changes in regulatory conditions, shifts in customers demand and evolving competition are environmental transformations that require the engagement of BMs practices (De Reuver, 2009). A similar dichotomy is presented by Baden-Fuller and Haefliger (2013), who evaluated how innovation links to performance through the business model and how changes in the business model influence technological innovation. Thus conceived, the business model can be a vehicle for innovation as well as a subject of innovation (Zott et al., 2011)

On a theoretical perspective, Al-Debei and Avison (2010) identify BMI as the mediating instrument between the company's strategy and the company's operations. On a more practical perspective, Tongur & Engwall (2014) evaluate the intersection between technology and BMs by defining a compound of technology and service innovation as the solution for the business model dilemma, which companies face when implementing new technologies.

Foss and Saebi (2017) proposed a framework that evaluates technology as part of the external environment, which has a direct impact on the company's business model (Figure 1). The innovation of the company's BM is structured on two axes: novelty and scope. The former evaluates the amount of architectural and modular changes brought by the external environment; the latter identifies whether the technological changes are new to the company or to the industry. This framework represents a generalization of the recent literature, which focused on the innovation and redesign of companies' BMs or BM components (Berends et al., 2016; Cortimiglia et al., 2016). Similarly, some studies have proposed tools to evaluate BMs robustness (Haaker, 2017) and implementation of BMI roadmaps (Toro-Jarrin, 2016; De Reuver, 2013).

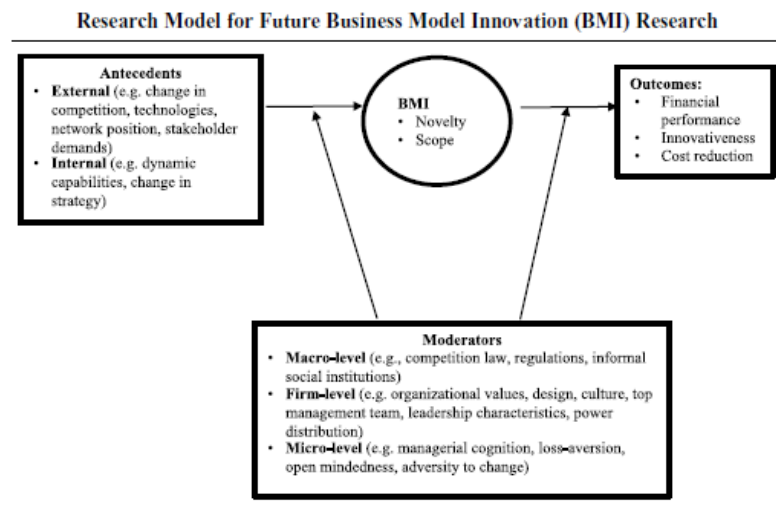


Figure 6.1: Business Model innovation framework (retrieved from Foss and Saebi (2017))

6.2.1 Business Model Stress Testing

Since technology's future development is uncertain, Janssen, Lankhorst, Haaker, and de Vos (2012) introduced Business Model Stress Testing as a tool to evaluate the robustness of a company's BM by assessing the impact of a collection of alternative environments. This approach includes a Heat Map that shows the robustness of the BM's components towards certain scenarios or future developments. De Reuver (2017) defines robustness as the ability to remain feasible and viable in a changing business environment. Therefore, robustness addresses the long-term soundness of a BM (Bouwman et al., 2012). This approach not only identifies the BM's robustness, but it also identifies how BM's components are affected by external factors.

Bouwman et al. (2012) formulated the Business Model Stress Testing tool as a six-step method:

6.2.1.1 Selection and description of the business model

The first step consists of a structured description of the current BM. Some of the most used BM's design approaches are Osterwalder's CANVAS method, the approach described by Ballon (2004,2007,2009), the Gordijn's value model (Gordijn and Akkermans, 2001), the Bouwman's STOF approach (Bouwman et al., 2008), and the El-Sawy's VISOR model (El-Sawy et al., 2013). The approach will make use of the CANVAS approach since it more

suitable for the analysis of an individual company rather than the entire ecosystem. Moreover, this approach evaluates the organization's BM as structured in different domains providing a complete evaluation method.

6.2.1.2 Identification and selection of the stress factors

The second step consists of the selection of trends, uncertainties and future outcomes that describe the expected future environment. Since the objective of this analysis is the evaluation of the technology, the scenarios selected are related to the different technology use-cases. The validity of the stress test very much depends on the quality of the input and on the choice of the stress factors.

6.2.1.3 Mapping of BM to stress factors

This step consists of the actual stress test, where the stress factors selected in the second step are compared with the components of the BM, which were evaluated in the first step. First the causal relations between stress factors and BM's components are evaluated. These relations be straightforward or more latent. A clear picture of how uncertainties relate to BM choices emerges.

6.2.1.4 Heat Map

This step consists of estimating or determining how stress factors affect the BM's components. A Heat Map is drawn in the form of matrix to evaluate the impact of a specific uncertainty outcome on the BM. A colouring scheme is used to evaluate the impact:

- Red: Possible show-stopper which might turn the BM component no longer feasible.
- Yellow: The BM component might be no longer viable in case of scenario's happening.
- Green: The outcome of the stress factor does not affect the viability and feasibility of the BM component in a negative way.
- Grey: The outcome of the stress factor has no relevant influence on the BM components.

6.2.1.5 Analysis of the results

The heat map's analysis aims to provide insights on the BM weaknesses. A sub-view analysis allows to zoom in on the major problem areas of the BM. It can also evaluate which stress factor has larger positive or negative impact on the BM components.

6.2.1.6 Formulation of Improvement and actions

The BM's vulnerability analysis revolves into recommendations to address the weak components in the BM. This process is aimed at improving BM consistency with the technological environment. A reasoning behind the choices behind a specific colouring are provided. The limitations have to be stated. First the stress test evaluates the impact of a specific trend, but the likelihood of such development is not analysed. Second, the initial choice to analyse the technological environments does not include scenarios related to different uncertainties or trend that the company may face in the future.

6.3 Selection and Description of the Business Model

The starting point of our BM stress test is a shared understanding of what the company's BM actually is. Therefore, it is necessary to adopt a BM framework that is understandable by everyone, simple and intuitive. However, it also should not oversimplify the complexities that characterise the Portbase role. Therefore, this research project makes use of the CANVAS model (Osterwalder and Pigneur, 2002; Osterwalder and Pigneur, 2003; Osterwalder and Pigneur, 2005; Osterwalder and Pigneur, 2010) as a tool to describe and understand the company's BM. The reasons behind the choice of BM CANVAS compared to other models is justified by its wide-spread use on the market. Moreover, the BM CANVAS focuses on the analysis of the singular organization rather than the industry ecosystem, which is in line with the objective of this section. Finally, BM CANVAS enables the conceptualization of the company's BM in one workshop session.

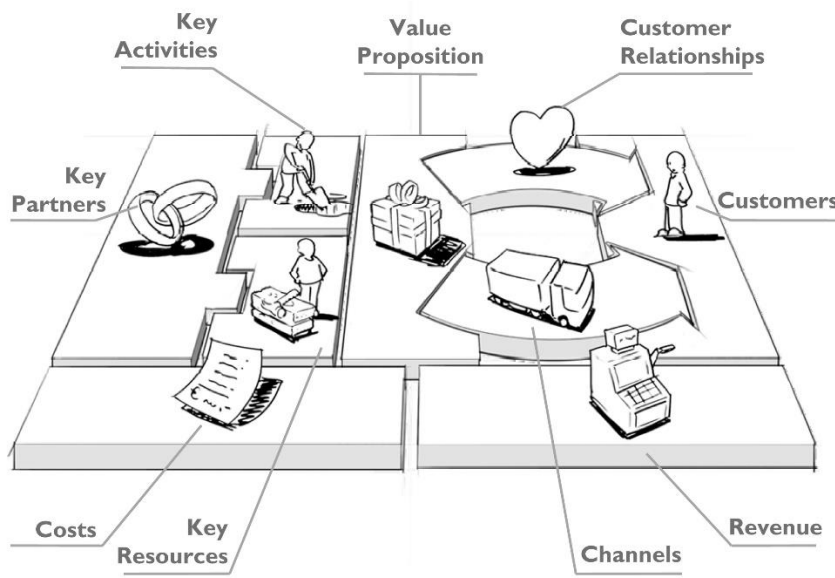


Figure 6.2: Business model CANVAS visualization (Osterwalder and Pigneur, 2011)

6.3.1 BM CANVAS Description

The model consists on nine basic building blocks that identify the logic based on which the organization generates values and makes profit (Osterwalder and Pigneur, 2011). Figure 6.2 provides a visualization of the nine building-blocks, which are described as follows:

- **The Customers Segments:** It defines the different groups of people/organizations that that the company aims to serve. Since the enterprise's success directly depends on its customers, those represent the hearth of the BM. Customers are usually grouped into different segments based on their needs, behaviour and other describing attributes. By deciding which segment(s) to address, the company should design its BM around the understanding of the customer's needs.
- **The Value Proposition:** It describes the company's products and services that generate value for the targeted customer segments. It usually solves a customer problem or satisfies a customer need. As described by Tongur & Engwall (2014), the value

proposition represents a bundle of products and services, or an aggregation of benefits that companies offers to customers. In BMI, some value propositions can be new and disruptive, while others may be similar to existing value offers, but with added features or attributes.

- **Channels:** It describes how a company gets in touch with its customers and delivers value propositions to them. Channels are meant to raise customers' awareness on the service delivered. The company's interface with the customers is characterized by communication, distribution, sales channels, and after-sales customer's support. These relationships range from personal to completely automatized.
- **The Key Partnership:** It identifies the network of partners who contribute to making the BM working. It identifies dependencies with partners and optimal alliances to optimize business model reducing risks and acquiring resources.
- **The Revenue Stream:** It describes the earnings that the enterprise generates from its customer segment. Therefore, the company should reason on the questions: "For what value are the different customer segments willing to pay?". This leads to the generation of different revenue streams per each customer segment, which can differ according to different pricing technique (fixed prices, bargaining, auctioning, market dependent, volume dependent, yield management).
- **The Key Resources:** It describes the necessary assets to make the company's BM working. Key resources consist of physical, financial, intellectual, or human. Moreover, these key resources can be owned by the organization, lease or acquired by external parties.
- **The Key Activities:** It describes the company's activities that make the BM work. They are required to generate value to the customer, reach the customers and maintain relationship with them, earn revenues.
- **The Cost Structure:** It identifies the relevant costs when operating under a particular BM. It evaluates the main cost factors in creating and delivering value, maintaining customer relationships and generating revenues.

6.3.2 Analysis of Portbase Business Model based on CANVAS model

6.3.2.1 The Customers segments:

Every actor in the logistic chain is a potential customer of Portbase. In particular, all the actors in the port environment are customers and target for one or more PCS services. As shown in Table 3.1 (pag.32), the stakeholders in the port environment can be classified in five main groups according to their role in the process. Portbase internally provides a further classification by distinguishing the users in strategic customers, ordinary customers and authorities:

- **Strategic customers** include the shipping lines and the terminals. They are strategic because they manage a large part of the container market and they make large use of the PCS. They have periodic joint discussions to evaluate existing services of Portbase as well as developing new services. They contribute to the company's income by paying annual, service and per-use fees.
- **Ordinary customers** usually comprehend SMEs operating in the port environment. This group of users are characterised by smaller margins and low benefits from the

use of PCS as an information system. However, their participation in the system is beneficial to improve the process coordination and the port digitalization. Therefore, there are some companies such as road/barge and rail companies that are subsidized by the port authority and they can use the PCS without incurring in any cost. Planning their visit at the terminal has a major impact over the process visibility and the port performance by decreasing the congestion and increasing the throughput rate. Certain market parties provide key information to the system, but they would not participate in the PCS if they had to pay.

- **Authorities** are defined as the governmental authorities (customs, river police, veterinary, Rijkswaterstaat, Emergency Services) and the port authorities (Port Authority, Harbour Master). The Port Authority and the customs, through the portal “single window”, adopted the PCS as the only communication channel to talk with the parties on the process. Moreover, the Port of Rotterdam represents the main and only investors of Portbase.

6.3.2.2 The Value Proposition:

Portbase offers standardised and specific services according to the messaging needs of the customers. By analysing the company’s services, it is possible to define a common denominator, Portbase aims to increase the vertical and horizontal collaboration among companies through process standardisation and information sharing. Once a company connects to a service, it is also more convenient for the other companies to connect to that service, so that they can standardise their process no matter which company they deal with.

Despite the parties are not forced by any authority to make use of the PCS, some services are available only via PCS since some customers appointed Portbase as the communication facilitator system. For instance, the port authority selected the PCS as their window for some notifications. Similarly, the automated terminals only allow booking through the PCS, as well as the communication to customs through the single window.

6.3.2.3 Channels:

The channels used are different according to the different company’s customers, strategic and ordinary. Regarding the ordinary customers, Portbase developed a sales team to advertise the services, who reaches the companies on the market via phone and other P2P means of communication. Once the meeting has been arranged, the sales people make visits at the customers location, which is usually in the port area. Moreover, Portbase makes use of the website and emails to inform the customers about changes in the service and other important notifications. Since there are several parties we don’t communicate directly with, the company’s website plays an import role in communications. The company is now working on community engagement tooling to increase the level of engagement, without meeting the customers in person.

Portbase organizes periodic meetings with strategic customers to define the service quality and pricing policies. Moreover, these meetings are meant to discuss the strategic direction of the company and the new services to be developed. Operationally speaking, there is a service desk that every customer can reach by phone or email for complaints or service interruptions.

Once a company decides to join the PCS network, it goes through a configuration period where the organization’s ERP gets connected to the PCS through APIs. This process enables the company to exchange information back and forth with the system. This ITC channel is used by the company to deliver the services and generate value for the customer.

6.3.2.4 Customer Relationships

The relationships established with strategic customers can be defined as partnerships. Portbase adapts, modifies and innovates its services based on the requirements and feedback provided by strategic customers. Similarly, the strategic customers disclose some features of their strategy to evaluate new service opportunities from Portbase. In this perspective, Portbase facilitates and enables the development of its customers changes in business models. The ordinary customer relationships does not imply structural and periodic relations with them. For instance, SMEs, especially those providing the hinterland transportation, do not exchange feedback with Portbase and do not contribute in innovating the company's services.

6.3.2.5 The Revenue Stream

Portbase raises revenues from the different types of fees asked to customers for the company's services. Paying an initial connection fee, the party becomes part of the network by getting connected to the PCS via APIs. Once in the system, the customers pay a service recurring fee and a per-use fee. For instance, a service can cost 20 euros per month as fixed fee plus a fee per transaction.

Portbase is a no-profit organization which uses the revenues to repay the systems creation and development. At the development stage, the company and the strategic customers make predictions about the service future utilization in order to define the pricing of the newly developed service. The pricing takes into consideration the total cost for developing, running and maintaining the service for a certain period. Over time, there is the chance to drop the price in case the system does not show enough market adoption or enough benefits for the ecosystem. In this case, the prices can be changed even if the service is already in place.

Since there are some customers identified by a small business size and reduced profits, the Port Authority decided to exempt these SMEs organizations from the service fees. These parties provide key process information for the coordination improvement. Therefore, it is worth including them in the network despite their null financial contribution. Moreover, the port of Rotterdam fully contributes in paying salaries of Portbase employees and other overhead costs. This enables Portbase to be highly competitive and to set the prices below market prices. This pricing strategy helps to develop a healthy port ecosystem and enhance the port competitiveness.

6.3.2.6 The Key Resources

The key financial resources of the companies are provided by the shareholders, who cover the salaries and overhead costs. Since the company can be defined as an IT organization, the staff represents a key resource. Therefore, data analysts and data architects generate the real value provided to the customers out of the information received as an input. Similarly, the business managers and the service innovation consultants that frequently meet with the customers represent a key resource in the development of new products and services. The sales team is a resource in establishing and maintain good customer relationships. However, the company's feature of "trust" is one of the most valuable resources, which lays behind the adoption of many organization of the PCS as a mean of communication.

6.3.2.7 The Key Activities

The key operational activities performed by the organization consist in the data receipt, information extraction, and information sharing. By extracting the information from cargo documentation and combining them with other information source, Portbase is able to generate value for the customers. This information sharing with Portbase is rooted in the reciprocal trust and the identity management software.

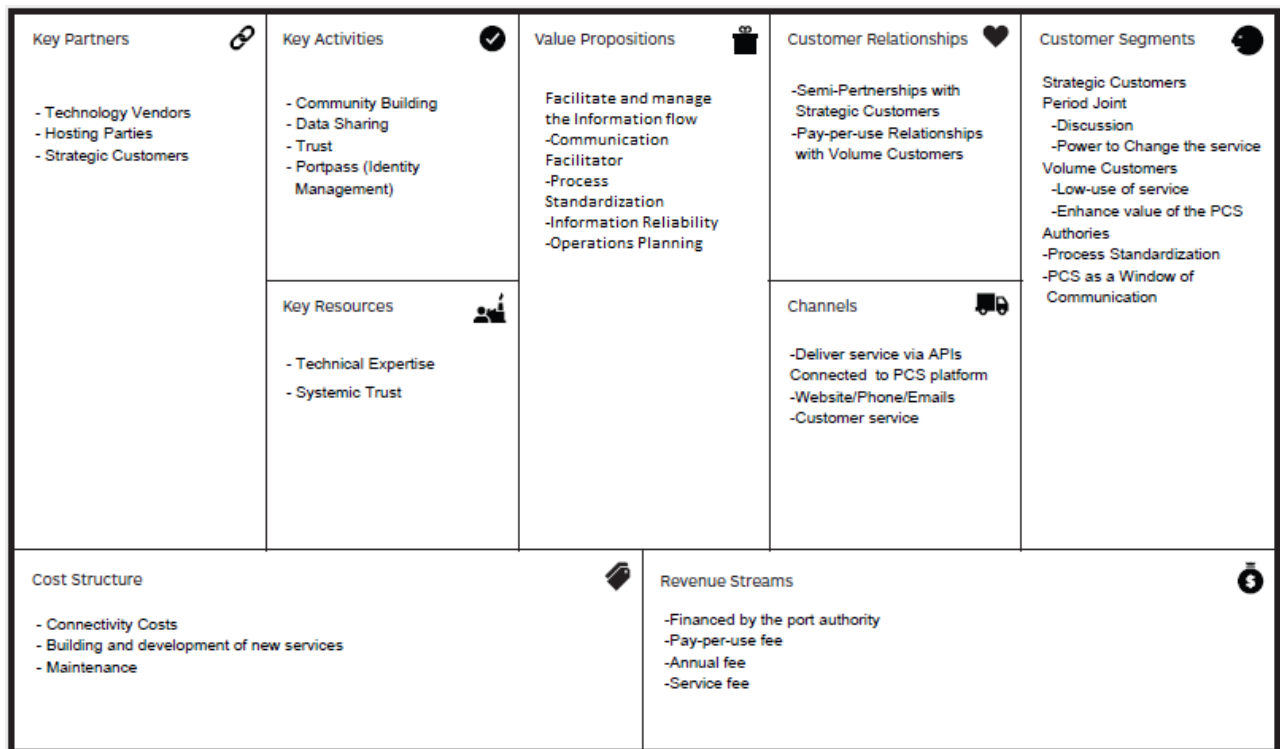


Figure 6.3: Business Model CANVAS applied to Portbase analysis

6.3.2.8 The Key Partnership

The company defines itself as an IT company, which automate port processes managing a large amount of information about the process and an extensive network. Therefore, the company's core business is not developing software. This implies that Portbase has established partnerships with several technology vendors. However, the company is not technology innovators or an IT company to host software. The hosting party and the cloud service provider are strategic partners. Furthermore, the organization often hires external programmers, consulting companies and staffing companies to improve the knowledge already in-house. Moreover, it hires expertise in certain field (I.e. data scientists).

6.3.2.9 The Cost Structure

The major costs of the companies consist in connectivity costs, production costs of building and developing a new software or services, maintenance and hosting costs. Building a service with a certain software or cloud provider and maintaining that. Moreover, the governance part of staying connected to the community and making sure that the company satisfies the real customer's needs. Marketing investigation for new services are usually are not allocated in the pricing strategy.

6.4 Stress Factors Identification

This section aims to identify the stress factors to perform the stress-test analysis. In accordance to the research objective, the chosen stress factors are related to the potential blockchain implementations. From the scenarios of analysis two main stress factors were identified:

- **External company developing a blockchain solution for cargo information.** This first stress factor assesses the potential impact that a blockchain solution for cargo information would have on the Portbase’s business model. Since the consortium of companies led by Maersk is already developing such a solution, analyzing this scenario has a significant practical significance. This scenario would see Portbase managing a reduced amount of documentation transactions since many of the services offered by the company would suffer from the inexpensive, consistent and accurate source of information. We selected as extreme outcomes: “blockchain solution used only among the parties in the legacy” vs. “blockchain solution used by all the parties operating in the port environment”.

- **Portbase internal development of a blockchain solution for process information.** This second stress factor appraises the Portbase’s choice to develop a blockchain solution internally with the objective to increase the process visibility. Currently, the process stakeholders are not willing to share process information since they threatened by the chance to have commercial information spill-over. By implementing a blockchain solution to store and transact this information, no third-party would have access to the information other than the information sender and recipient. This would kick start to a process of information sharing that would ultimately improve the overall process performance. We selected as extreme outcomes:” blockchain solution does not increase the information sharing but it redirects the current transactions” vs. “blockchain solution enhance the willingness to share information”.

6.5 Stress Factors impact on Business Model and Heat Map

This section provides an evaluation of the business model components’ robustness with respect to the impact provided by the two stress factors identified (Table 6.1). Moreover, this analysis shows the casual relations between the stress factors and the business model components.

Table6.1: Impact of uncertainty outcomes on selected BM components

Outcome	BM component	Impact and Coloring
Blockchain Solution for cargo Information used within the legacy	Customer Segment	-Volume customers have low switching costs, so they could easily adopt a blockchain solution; -Strategic customers would follow the market needs and connect to the blockchain solution;

	Revenue Structure	The revenue deriving from the cargo information transaction among the legacy partner would be reduced in size. Strategic customer would have more buying power to decrease service prices.
	Value & Services	A reduced network implies less information transferred via the PCS. This implies less network externalities and a lower process standardization.
	Key Activities	Less cargo information at hand enables less reuse of information and a weaker service.
Blockchain Solution for cargo information used by the entire port ecosystem	Customer Segment	Not only volume customers and strategic customers would adapt their processes to this solution, but authorities can decide to use the blockchain as a single window of communication.
	Revenue Structure	Revenue from services managing cargo documentation would be eliminated
	Value & Service	Large part of the PCS network would disappear, this imply a reduced potential to standardize operations and attract further companies.
	Key activities	The PCS would be used only for transacting process information and planning cross-organizational activities
Blockchain solution for process information, which increases the willingness to share information	Channels	The solution consists in building a blockchain layer on top of the current software. This would represent the mean of communication for process information.
	Customer Relationships	This solution implies a stronger relationship with volume customers, who need to become an information provider
	Key Activities	The role of the company regarding the process information transaction is to validate the information recorded on the ledger.
	Value & Service	The trusted role played by Portbase is strengthened by the role as validating party of a blockchain transaction recording.

The heat-map represents a visualization of the different outcomes expected from the stress factors impact onto the BM components. As shown in 6.2, both outcomes regarding the blockchain implementation for cargo documentation are showstoppers for the business model component "Value Proposition". This is mainly due to the eroded value of the network, which generates a decrease in process standardization and network externalities. Similarly, such a stress factor would affect the customer segment, on each type of system's customers. This can lead to the decision of the port authorities and governmental agency to connect their single window to a blockchain solution rather than prioritizing the use of the PCS. All these factors can generate a significant impact on the Revenue structure, that would lose part of its income deriving from services.

In case Portbase decides to implement a blockchain solution for process information, which enhance the parties' willingness to share information, the company's BM would benefit in terms of Value Proposition and Customers Relationships. This solution is expected to attract

parties that are currently outside of the process to collaborate in the information sharing. This network expansion would reinforce the Portbase role as a trusted party that validates the information transaction on the network. However, this solution also implies high connectivity costs and the redesign of the revenue structure, which cannot ensure high profit from the use of a blockchain solution.

Table 6.2: Stress-Test Heat Map for Portbase

Key Activities	Cargo documentation blockchain		Process Information blockchain
	Confined to the legacy	Applied by the entire ecosystem	Blockchain increases the willingness to share information
Customers Segment			
Customer Relat.			
Channels			
Value Proposition			
Key Activities			
Key Resources			
Key Partnerships			
Cost Structure			
Revenue Structure			

6.6 Portbase Disintermediation and Reintermediation

The business model stress testing puts the emphasis on the disruptive role of blockchain technology with regards to Portbase as an information intermediary. It highlights the lack of robustness and viability in the company’s business model with respect to the two stress factors taken into consideration. This section aims to provide recommendations to Portbase on how to adapt its business model in response to a blockchain implementation. First, an analysis of the current literature on disintermediation will be provided to evaluate the opportunities of current intermediaries towards the implementation of a complete decentralized system as blockchain. Second, the potential roles played by Portbase in case of a blockchain implementation will be identified and described. Combining the theory of disintermediation and reintermediation with practical knowledge of the case study, this analysis aims to provide a set of solutions for Portbase and other information intermediaries.

6.6.1 Blockchain and the Internet: an equivalent path

The market implementation of new information technologies, such as blockchain, has a major impact on threats and opportunities to the market intermediaries. The literature on the topic

often postulates that the open and decentralised nature of the blockchain will lead to the complete disintermediation. For instance, Vigna (2014) describes the crypto-libertarian “Declaration of Bitcoin’s Independence”, which states: “Blockchain does not pander to power structures, it undermines them” (Vigna, 2014). Moreover, in the first conceptualization of blockchain, Nakamoto (2008) repeatedly points out that one of the major advantages of blockchain consists in the removal of third parties.

Similarly to the blockchain phenomenon, the early 1990s saw the birth of the internet and the rise of cyber-libertarianism. In the 1996, John Perry Barlow published the “Declaration of the Independence of Cyberspace”. Despite these initial premises on the use of internet, later developments have proved the opposite, showing the rise of new intermediaries who perform social and economic functions. This is the proof that intermediaries can adapt their business models in order to maintain value-adding roles (Barling and Strak, 1998; Scott, 2000). As Goldsmith and Wu (2006) argue: “the rise of networking did not eliminate intermediaries, but rather changed who they are. It created a whole host of new intermediaries”. Bailey and Bakos (1997), identify four potential roles for intermediaries that are facing disruptive information technologies: (1) aggregating the demand of many customers and/or the products of many suppliers, (2) preventing opportunistic behavior and generating trust, (3) facilitating the exchange of information, and (4) matching customers and suppliers. Janssen and Sol (2000) build on this categorization by classifying the intermediary’s role into: information, translation, coalition, matching, trusted, and monitor. Each of these roles give rise to new and different business model that original intermediaries can adopt in response to change in the technological environment.

Yee (2015) notes how blockchain implementation resembles the internet introduction in two important respects: blockchain builds an information network and its applications are generative. The author compares the two inventions to derive similar development paths and he concludes that intermediaries will emerge as soon as the technology will be incorporated into mass social and commercial practices. To this end, the following section attempts to provide an analysis on the potential future role of Portbase as an intermediary in port logistics.

6.6.2 Portbase Reintermediation

This section aims to provide Portbase with a set of recommendations on the future roles that the company can play as an information intermediary at the port of Rotterdam. This guidance is provided with a business model perspective by comparing the technology’s use cases with the intermediary’s roles. On the one hand, the technology implementation business cases are defined as the four business cases described in Chapter 4: blockchain used to store and transact cargo information, blockchain used to store and transact process information, blockchain used to improve trade finance, automatization with IoT and Smart contracts. On the other hand, the intermediary’s roles are derived and adapted from the classification provided by Janssen and Sol (2000). The Dutch authors classified the intermediary’s roles in a clear and complete framework, which represents a valuable starting point for the Portbase’s future role analysis. In particular, this study will evaluate the adoption of the intermediary’s roles as information, translation, trust and monitoring agents; discarding the roles as aggregating and matching agents. The reason behind this choice lays in the neutral role played by Portbase in the port environment of Rotterdam. First, a brief description of the intermediary’s roles will be provided based on the Janssen’s and Sol’s categorization (Janssen and Sol, 2000). Second, the potential Portbase’s business models will be described.

An information intermediary is an information aggregator that collect and store data on behalf of buyers and sellers to redistribute them (Janssen and Sol, 2000). It can be classified as content agent and collaborative agent. A content agent gathers data from several sources and it extracts useful information on the content. A collaborative agent filters irrelevant information from the input data. A translation agent transforms data provided by a system or party into another format that is readable by the information system of another party. A trusted agent can perform four tasks: identifying, authorizing, transitional, and time-stamping (Frooming, 1997). Finally, the monitor agent plays a role at the margin of the system processing information intelligently based on the monitoring of the status of tasks.

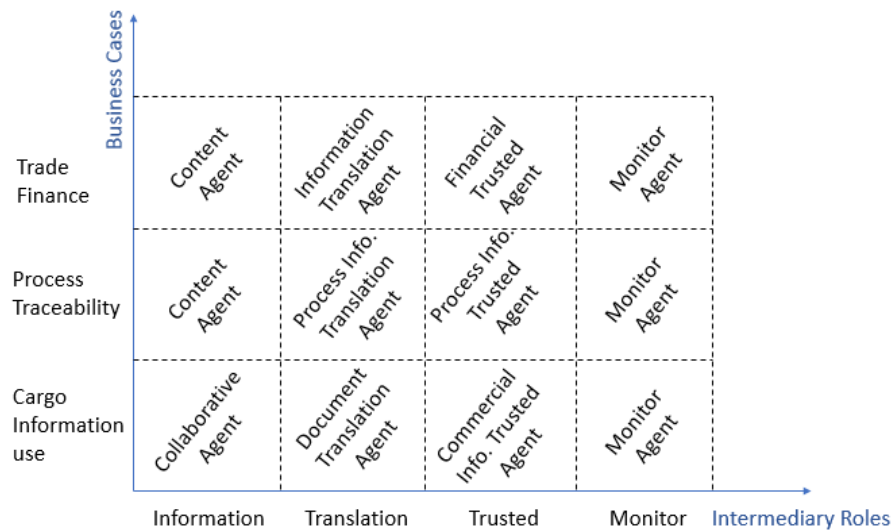


Figure 6.4: Portbase Reintermediation Opportunities

6.6.3 Information Intermediary

Portbase has currently the role as the port inter-organizational information system, which gathers, stores and shares information. The implementation of a local/global blockchain where each party writes information and give access to other parties makes this current role obsolete. However, the role as an information facilitator who coordinate the process of information exchange holds validity even in case of a blockchain solution. This role is specifically useful to avoid the spill-over of commercial information, which represents one of the main threats of the parties in the supply chain. Specifically, a content agent is in charge of gathering data from different sources and extract valuable information. This role could be played by the Portbase under the hypothesis that several blockchains or information systems will characterise the port logistics. The private company could get access to the data stored in these systems with the objective to extract the necessary information before sharing them with the parties who ultimately make use of this information. This role is specifically meant for the second and third blockchain business cases, since a large amount of data is available and the access mechanism is not well structured. On the other hand, the collaborative agent has the role to filter irrelevant information and redistribute them. This solution is suited for the first blockchain business case, where cargo documentation requires filtering in order to avoid commercial information spill-over. Therefore, Portbase would play the role as an information filtering agent of the data stored and transacted via blockchain.

6.6.4 Translation Intermediary

The blockchain adoption and technology's implementation in a company's daily activities is a costly process, which cannot be affordable to many of the SMEs working in the port environment of Rotterdam. This could lead to a scarce or limited adoption of a technology that establishes its real worth in a network size. Therefore, Portbase could ensure the access to a global blockchain to those SMEs that have not the resources to do so. By doing so, the single company would communicate the specific process or cargo information to Portbase, who works as an intermediary and records it on the ledger. Similarly, the single company can query Portbase to retrieve data from the blockchain on behalf of them. This role of Portbase could prevent the barrier for a blockchain implementation accelerating the process of adoption as well as the fair development.

6.6.5 Trusted Intermediary

The adoption of a private blockchain over a public solution in the field of logistics requires the figures of a central orchestrator, who regulates the access to the ledger, the party's identification as well as the information transaction validation. This neutral and trusted party is meant to prevent the different organizations from behaving opportunistically, safeguarding the market fairness. In practice, Portbase would check that a digital identity corresponds to an entity in the non-digital world. These proofs of identity are necessary to get access to a private blockchain platform, and consequently, to write and retrieve the information on and from the ledger. The proof of identity is translated into public and private keys, which are issued by Portbase, who acts as the authority monitoring the transactions that take place on the ledger. This role as system authority would shift from the current central position in the information transactions to an external and regulatory role over the system. In case of cargo information transaction via blockchain, Portbase would ensure that the parties communicating via blockchain do not have a commercial threat from a blockchain solution. This is possible by safeguarding the commercially valuable information contained in the cargo documentation. In case of process information transaction via blockchain, Portbase would prevent smugglers and unauthorised party from accessing the information.

6.6.6 Monitor Intermediary

The role as a monitor intermediary is marginal compared to the ones previously described. It consists in transforming Portbase in a platform, on which the several parties working in the port environment can develop or connect their specific applications via APIs. The creation of a platform would enable the different information system to connect and exchange information. In this objective of connecting the different information systems, Portbase has a large potential since it can exploit its feature of neutrality. However, Portbase would not have a direct role on the information flow, it would rather intervene in case of malfunctions or issues among the parties.

7. Conclusions and Recommendations

Despite the large interest that blockchain technology has received starting from 2014, literature on the blockchain in application to port logistic is still very limited. This research contributes to this field by identifying potential blockchain business cases and assessing their impact. Moreover, this study evaluates the disruptive role of the technology on the business model of the port inter-organizational information system, proving recommendation on the business model adaption to a blockchain implementation.

This research started with a literature review and a case study description, which served as a basis to build the business cases analysis framework. This was followed by empirical research with the objective to evaluate the blockchain potential for port logistics. Finally, the analysis of the Portbase's current and future potential business models led to answer the main research question:

How does blockchain technology affects port logistics and what is the impact on Portbase's business model?

This chapter aims to summarise the findings of this research project. Moreover, it derives recommendations as well as future research directions.

7.1 Findings

To achieve the research objective four sub-questions have been derived. As follows we will analyse the main findings relative to each sub-question in order to retrace the main path of this thesis project.

SQ1: What are the key features of the blockchain technology in application to port logistics?

The literature review represents the theoretical background on which this thesis project is erected. It provides an understanding of the topic of blockchain and inter-organizational information systems, which is pre-requisite for the comprehension of the blockchain business cases. The blockchain has been described by differentiating among platforms, applications, and services. On the one hand, the concept of platform enabled the description of the technology's building blocks, such as network architecture, transaction mechanism, consensus mechanism, the four P's. On the other hand, the concept of applications introduced the features of smart contracts and internet of things.

SQ2: What are the potential use-cases of blockchain in application to port logistics and what are the port performance indicators to evaluate them?

The classification of the current blockchain market applications was fundamental to derive the blockchain business cases for port logistics. Once retrieved, the market applications were classified based on the functionalities provided and, consequently, grouped according to their similarities. This process led to the definition of four business cases that use the technology to: store and transact cargo information, store and transact process information, improve trade finance, automatize the process through smart contracts and internet of things. To derive

these business cases, the definition and analysis of the import carrier process as a case study provide the researchers with an in-depth understanding of the port processes.

SQ3: What is the impact of the blockchain use cases on the port processes in terms of information, physical and financial flows?

The blockchain business cases defined in the previous research sub-question were tested against a set of KPIs specifically selected for the analysis of the port information systems. Interviewing the main actors in the port environment, the business case's impact was evaluated. The use of the technology to store and transact cargo documentation is expected to increase the accuracy and consistency of the information flow. This leads to a more accurate customs risk analysis, increasing the efficacy of the customs inspections and consequently decreasing the process lead-time. The use of the technology to store and transact process information leads to an increase in process visibility and consequently in process coordination. This is beneficial for the process steps of in-terminal container reshuffling as well as hinterland transportation planning. The use of the technology to improve trade finance enables an integration of external parties (financial institutions) in the process, decreasing waiting time for commercial clearance. Finally, smart contracts and internet of things represent automatization mechanisms capable to generate a large amount of process information and eliminate non-value added process steps.

SQ4: What is the current Portbase business model and how can it be adapted to a blockchain implementation?

The previous three sub-questions inspected the impact of blockchain on the port processes. The fourth sub-question analysed the impact of blockchain on Portbase as a private company, which works as an information intermediary in the port environment. This analysis started with a description of the current business model and value generation of Portbase. Subsequently, the robustness and viability of the business model elements have been tested against two selected stress factors. A strong negative impact of the stress factors on the business model elements was derived from the analysis. These results led to the evaluation of the future potential solutions that Portbase can embrace to adapt its business model to a blockchain implementation. By deriving the intermediary's roles from the literature and applying them to the context of Portbase, it was possible to describe four future roles for Portbase: information, translation, trusted, and monitor intermediaries.

MQ: How does blockchain technology affects port logistics and what is the impact on *Portbase's business model*?

This research practically and theoretically contributes to the research field of blockchain in application to port logistics. First, it derives four blockchain business cases for port logistic, which are tested in terms of impact on physical, financial and information flows. Second, it shows how these blockchain solutions have the potential to improve four process steps: in-terminal container reshuffling, customs clearance, commercial clearance, and hinterland transportation planning. Despite this positive impact on the port performance, a blockchain solution can contribute negative to some of the current Portbase business model elements, as derived from the stress test tool. Finally, some potential roles of Portbase are evaluated and recommended with the objective to adapt the company's business model in response to a blockchain solution. In particular, four main roles are derived: information, translation, trusted and monitor intermediaries.

7.2 Discussion

This research project was commissioned by Smartport with the objective to investigate the blockchain potential in application to port logistics. In a scenario characterised by private companies and consortia of organizations launching blockchain pilots for logistics, the port authority perceived the decentralised technology as a threat to its power on the port environment. Therefore, Smartport, on behalf of the port authority, has launched this research project aimed at reinforcing the role of the port of Rotterdam as the largest and most innovative commercial port in the Europe. Together with this thesis research, the collaboration between Smartport, TU Delft and Erasmus University of Rotterdam led to the creation of an informative white paper addressed to the companies working in the port environment (Francisconi et al., 2017).

The findings of this research are based upon an in depth qualitative research using both primary and secondary data. To increase the research validity, study triangulation of information has been used. The blockchain business cases were identified through desk research, and then validated in the case study and through the interviews. This increases the internal validity of the research. External validity is low, however since the research is explorative in nature its results are not meant to be generalized across other cases.

Due to its novelty and limited supplication, blockchain is still immature. Therefore, all data used in this research is empirical data that describe the perceived effects, issues and benefits. Therefore, the results of this study identify perceived consequences instead of real consequences. Moreover, the assumptions made could not be tested quantitatively due to the absence of pilots or available data on blockchain applications.

Since blockchain technology is still immature, much of the expected benefits provided by the technology are exaggerated in terms of impact by the parties who aim to profit from the technology implementation. This generates a huge hype on the blockchain creating misunderstandings and misconceptions on the real benefits as well as potential use-cases. This is confirmed by Gartner, which identified the blockchain at the peak of the hype cycle for the whole 2017 (Panetta, 2017). However, blockchain is not a panacea for all sorts of problems that characterise today's logistics sector. This research demonstrated that some use-cases might have a positive outcome in terms of process optimization. However, the benefits provided have to be compared with the costs of blockchain implementation to evaluate the real advantage provided by the technology.

In the research process, methodology and argumentation bias tried to be lowered as much as possible through various approaches. First, following the guidelines of Yin (2009) an interview protocol was defined and the sample was selected in order to collect the opinion of all the major actors involved in the port processes. Moreover, weekly in-depth discussion on both the process and the outcomes were conducted with my supervisor Yousef Maknoon. Second, in this research process, I tried to stay as close to the empirical data as possible. This principle was meant to reduce the risk of my own ideas or notions becoming more powerful than empirical data.

As identified in this research project, blockchain aims to enhance the process visibility and, consequently, the process coordination. However, looking back to the early 2000, these objectives were also at the basis of the Portbase implementation as the port inter-

organizational information system. Despite, Portbase has brought several improvements in terms of information sharing and process visibility, many parties are still profiting from opportunistic behaviours and information asymmetries. Therefore, the questions that practitioners should answer is: is blockchain the solution to the issue of process visibility when parties sometimes are not willing to share information?

7.3 Recommendations

This research attempts to throw light on the potential business cases of blockchain technology in application to port logistics. Supported by both desk research and empirical data, four main business cases are proposed as future potential applications of the technology. The findings suggest that researcher's attention should shift from the theoretical study of the blockchain technology, to the applicability of the blockchain in logistics as well as in other fields. The need for a cultural mind shift from a highly competitive to collaborative logistics environment lays at the base of the blockchain success in the field. Despite the recognition of the potential benefits, the main stakeholders showed scepticism in sharing information that may threaten their market competitiveness. Therefore, the business cases developed can represent a basis for further studies to test the applicability and subsequent benefits brought by the technology.

Due to the neutral role of Portbase, real data on the port information flow could not be retrieved and analysed. This prevented a quantitative analysis on the current situation to be performed, as well as assumptions on the impact of blockchain solutions to be made. Validity on this research was captured by a strong line of argumentation and an in-depth understanding of the port environment. This should provide this research with sufficient "trustworthiness", but a quantitative validation could support the findings.

7.3.1 Managerial Recommendations

The research concludes presenting a conceptual model on the potential roles that Portbase can play in response to a blockchain implementation. Despite the information technology is threatening the intermediary's role of Portbase, the private company can adapt its role to the four blockchain business cases. The range of roles suggested to Portbase are: information, translation, trusted, and monitor intermediary. Since most of the current market application aimed at implementing blockchain to logistics propose private and permissioned solutions, Portbase should decide whether to play a translation or a trusted role. On the one hand, in case of a translation role, the company would take care of the interfaces between the several private blockchain solutions and the existing information systems. On the other hand, Portbase would keep the current role as the neutral party introducing and managing a blockchain private solution at the port of Rotterdam. According to the future role played by Portbase, the technology development can be more or less democratic. Whether the private company decides to play an active role as a trusted intermediary, the blockchain solution developed can be used by every company no matter the legacy they belong to. Instead, if Portbase decides to play a translation role, the accessibility to the blockchain is limited to few legacies of companies.

7.4 Suggested areas for Future Research

From a scientific perspective, the goal of this research was to build a solid base for further blockchain literature in the field of logistics: a general overview on the topic on which further research can be developed upon. Therefore, there are a multitude of research directions that arise from this study. This section discusses the most important ones.

Quantitative evaluation of the blockchain business cases

The blockchain business cases evaluated in this research project represent only a limited part of the several opportunities that future blockchain start-up will develop. However, they are a solid starting point to evaluate the impact of blockchain solutions on logistics. To do so, it is necessary to quantitatively evaluate the impact as well as the implementation costs.

Further developing a blockchain analysis on port logistics

The current research project derives the results from a limited sample of respondents due to geographic and time limitations. This initial result can open the way to further inspections and studies in different ports or with broader samples. Moreover, it is valuable to inspect the impact of the technology to ports that are less technologically advanced than Rotterdam, which can vary in terms of use-cases and magnitude of the impact.

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Appendix A

Port Community System and Port of Rotterdam perspective

KPI		Cargo Documentation Transaction	Process Traceability	Trade Finance	IoT and Smart Contract Automatization
Financial	Freight bill Accuracy	1.1	1.2	1.3	1.4
	Overall Cost for the Information flow of a unit of cargo from the first to the last nodal point	2.1	2.2	2.3	2.4
	Average cost for detention/demurrage	3.1	3.2	3.3	3.4
Oper	Ship Turnaround time	4.1	4.2	4.3	4.4
	Road vehicle turnaround time	5.1	5.2	5.3	5.4

	Time spent by cargo awaiting commercial clearance	6.1	6.2	6.3	6.4
	Time required for customs clearance	7.1	7.2	7.3	7.4
	Time spent by cargo awaiting departure of next mode of transport (road or rail)	8.1	8.2	8.3	8.4
	Overall time of cargo in port	9.1	9.2	9.3	9.4
	Ship's capacity utilization	10.1	10.2	10.3	10.4
	Hinterland transportation modes' capacity utilization	11.1	11.2	11.3	11.4
Information	Security in information sharing	12.1	12.2	12.3	12.4
	Degree of Flexibility in using information technology	13.1	13.2	13.3	13.4
	Access speed to information	14.1	14.2	14.3	14.4
	Accuracy of information regarding status of shipment	15.1	15.2	15.3	15.4
	Provision of on-time updates of cargo information	16.1	16.2	16.3	16.4

Analysis

1.1 - The process of making freight bills does not always exploit data that are already available somewhere else, but they are the result of transcribed information.

1.2 – A better coordination between the physical and financial environments would increase the accuracy in freight billing.

2.2 – Process traceability would decrease the number of P2P communications to register a process step, which leads to a lower cost of communication. However, this can open the way to new services that are not in place yet. For instance, blockchain could provide information to improve the truck platooning efficiency. The front driving truck has less benefits than the last in the column. Blockchain could regulate the organization of trucks in order to make this advantage shared by the trucks. These are the new types of services that are enabled by the blockchain as a result of the new amount of data available. However, the basic process of picking up a container is still done by the PCS, which is the basic infrastructure service. This would create a blockchain enabled PCS.

2.3 – A better integration between physical and financial flows would decrease the number of communications taking place outside of the platform, decreasing the total cost for communication in the system.

2.4 - IoT and Smart contract lead to an automatization of the communications, decreasing the need for human intervention

3.1 – A more accurate and available information on the cargo leads to speed up the process and decrease the chances for delays due to customs controls, which implies lower detention and demurrage costs

3.2 – Process information would lead to a better coordination among actors, which results in a shorter time for arranging the customs/commercial clearances as well as the hinterland transportation. This could have a large impact on detention and demurrage.

3.3 – The implementation of a blockchain solution to improve trade finance would reduce the waste of time in communication and communication, decreasing the time spent by the container at the terminal, and as a consequence, the risk of detention and demurrage costs.

3.4 – IoT and Smart contracts would automatize some steps of the process and decrease the time spent by the cargo waiting for controls. This would ultimately decrease the chances for detention and demurrage costs.

4.1 – A more accurate documentation on the cargo could bring small improvement to the ship turnaround time.

6.3 – The communication to parties outside of the PCS network, such as banks, is made through old-fashioned means of communication. This implies a longer time required for the container commercial release. Including these parties in the network and improving the coordination with faster communications would decrease the time for commercial clearance

6.4 – An automatization of the communication among the different parties or an automatization of the nonvalue-added operations would lead to a shorter time for commercial clearance.

7.1 – Despite the process documentation is already in place and accessible, the customs have to run the risk analysis because the information might not be accurate enough, since they move from hand to hand before reaching the customs and they might be altered.

7.2 – Having a picture of the previous ports visited by the vessel or the stakeholder that handled the cargo could provide information to the customs in order to perform more accurate risk analysis.

8.3 – Blockchain in application to trade finance could speed up the process of commercial clearance which is one of the main causes for process delays. Eliminating process delays, it is possible to make a better planning of the hinterland transportation.

8.4 – IoT of Things and Smart Contract could automatize the process of cargo transportation towards the hinterland by providing faster process information and automatizing steps of the process.

9.1 – 9.2 – 9.3 – 9.4 Are the results of what said in the previous points

10.1 - “ship capacity utilization” can be improved by improving the cargo documentation, since your container can be left in the terminal if the documentation is not in order.

10.3 - An easier letter of credit procedure could impact the starting up of cargo. This latter improvement is not really related to the cargo side of process, but improving the trade finance could enable more companies to organize their supply chain and fill the empty capacity.

11.4 - In case smart contract are implemented combined with process’ deadlines connected to them, the hinterland transportation could be improved because the terminal knows which

container could still wait for a barge or for a road transportation and which not. The smart contract needs a deadline for the cargo to be in a certain point at a certain time.

12.1 - Some of the building attributes of the blockchain could enhance the security in information transaction. Therefore, blockchain can enhance security since it contain encrypted technologies in it. Blockchain not only can store the original document, but also a complete overview of the addendums. A customs department may have a document attached to the bill of lading saying that they had a certain security check and the cargo is cleared. You also want to have that document attached to the original document. Similarly, veterinary inspections can be updates to the original document.

12.3 – Storing documents such as the B/L in Blockchain technology would increase the transaction security and the chance to maintain the document tamper-proof.

12.4 - IoT and Smart contract have operational benefits but not in term of security because they provide an increased list of sensitive information.

13.1 Storing the cargo information and addendums on the chain leads to a faster process in information query, which decreases the P2P communications.

13.3 –The financial environment nowadays communicates outside the PCS, so a blockchain solution which include the financial information transaction would lead to an increased flexibility of the communication system.

13.4 - Smart contract and IoT allow new business models, such as truck platooning, therefore it increases the flexibility of the process.

14.1 - Blockchain provide a faster access speed to the information only in case this information is already on the chain from previous ports. In case this information needs to be registered, the time required in longer.

14.2 – 14.3 provide a faster access to process information compared to the current configurations.

15.1 – Since the cargo information is not handled by several parties, it is possible to achieve a higher information accuracy.

16.1 – 16.2 - 16.3 Blockchain is not the most efficient way to store and transact on-time information. However, the provision of process information that are currently not in place, the expansion of the network which leads to better coordination could provide some improvements.

Freight Forwarder perspective

KPI		Cargo Documentation Transaction	Process Traceability	Trade Finance	IoT and Smart Contract Automatization
Financial	Freight bill Accuracy	1.1	1.2	1.3	1.4
	Overall Cost for the Information flow of a unit of cargo from the first to the last nodal point	2.1	2.2	2.3	2.4
	Average cost for detention/demurrage	3.1	3.2	3.3	3.4

Operational	Ship Turnaround time	4.1	4.2	4.3	4.4
	Road vehicle turnaround time	5.1	5.2	5.3	5.4
	Time spent by cargo awaiting commercial viability	6.1	6.2	6.3	6.4
	Time for goods to be cleared by customs	7.1	7.2	7.3	7.4
	Time spent by cargo awaiting departure of next mode of transport (road or rail)	8.1	8.2	8.3	8.4
	Overall time of cargo in port	9.1	9.2	9.3	9.4
	Ship's capacity utilization	10.1	10.2	10.3	10.4
	Hinterland transportation modes' capacity utilization	11.1	11.2	11.3	11.4
	Information	Security in information sharing	12.1	12.2	12.3
Degree of Flexibility in using information technology		13.1	13.2	13.3	13.4
Access speed to information		14.1	14.2	14.3	14.4
Accuracy of information regarding status of shipment		15.1	15.2	15.3	15.4
Provision of on-time updates of cargo information		16.1	16.2	16.3	16.4

1.3 – By including the banks inside the port IOIS, it is possible to achieve a better accuracy of the freight billing time.

2.1 – Since the terminal requires and provides several cargo documentations, the total cost for information sharing is quite expensive. However, if the documentation were stored in the Blockchain the several transaction would not occur, leaving the terminal to simply get access to the information stored on the chain.

2.2 - Many process information are currently transacted through P2P means of communication. This leads to a redundancy of transactions to inform different parties about the same information.

2.3 – Similar to point 2.2 but specific to the communication between the parties in the process, the financial institutes and the consignor. (integration)

3.2 - The lack of process information in the process leads to a lack of process coordination, which generates several waiting times and it increases the chance of process detention and demurrage.

3.3 - The lack of coordination among the parties inside the port process and the financial institutions outside it leads to delays in communication. These delays increase the process lead-time and the chance for detention and demurrage.

3.4 – IoT and Smart Contracts would improve the amount of information provided to the system. Moreover, it would automatize part of the process transactions leading to a shorter process lead-time.

6.3 – Yes, it usually happens if the final consignee did not pay for the cargo then the container stays blocked at the terminal until it is paid or the original documents are handed over.

6.4 – IoT and Smart Contracts could feed the system with almost just-in-time information about the process, which could lead to automatize the process itself, decreasing the waiting time for commercial clearance.

7.1 - There is a problem with documentation accuracy, even when customs are sure about the containers documents, they have to do a risk analysis again on the TSD on the base of very brief and short information that was not taken from the first hand.

7.2 - The goal of the customs is to have better cargo information to carry out a better risk analysis. Nowadays customs do a lot of inspection because they are not sure about the information in the declaration and they receive a lot of false positive because of that, where they do not find anything. This represents a waste of resources, time and money. With better information, it is possible to make better risk analysis and have less inspection or better inspection, so that in the performed inspections, they really find something in the container that is not supposed to be there.

7.4 – Smart devices could provide information on the condition of the cargo, whether the container was open and others that might be useful for customs to generate a more precise risk analysis.

8.1 – If the documentations are not in place or in order, the container cannot leave to the hinterland.

8.2 – the carrier can only do the pre-announcement to the freight forwarder to arrange the hinterland transportation when the container is unloaded. They can also do it before, but then they would have the red lights, but the truck cannot enter the terminal and pick-up the container until the lights are all green.

8.4 – IoT could provide faster process information, increasing the coordination and decreasing the waiting time of the container for the hinterland transportation mode.

9.1 - 9.2 - 9.3 - 9.4 Are the results of the previously mentioned KPIs analysis

11.2 Lack of process information could generate delays in the process, which, as a domino effect, would delay the following process step, making barges or trains leaving without a fully-exploited capacity.

11.4 In line with the previous KPI, the IoT could automatize the generation of this process information.

12.1 A blockchain solution could prevent cargo documentation from being altered as well as cargo documentation not flowing along with the container and being handled by several parties.

12.3 Similarly to the previous KPI, if the B/L is stored in the blockchain, the system could be more secure against frauds. However, it is difficult to store such documents on the blockchain since many ports are not enough technological advanced to use e-documents.

13.3 – This configuration would lead to transfer some of the P2P communications that currently happen outside of the PCS, going through Blockchain as a IOIS. Therefore, this solution is characterised by an increase in flexibility.

14.2 – Since many process information is transacted with P2P communications, this solution would increase the access to the information being stored on the blockchain.

15.1 – Since the cargo documentation would not move from hand to hand, but stored on the chain as the initial stages of the transportation, this would increase the accuracy of the info itself

Ship Brokers and Agents perspective

	KPI	Cargo Documentation Transaction	Process Traceability	Trade Finance	IoT and Smart Contract Automatization
Financial	Freight bill Accuracy	1.1	1.2	1.3	1.4
	Overall Cost for the Information flow of a unit of cargo from the first to the last nodal point	2.1	2.2	2.3	2.4
	Average cost for detention/demurrage	3.1	3.2	3.3	3.4
Operational	Ship Turnaround time	4.1	4.2	4.3	4.4
	Road vehicle turnaround time	5.1	5.2	5.3	5.4
	Time spent by cargo awaiting commercial clearance	6.1	6.2	6.3	6.4
	Time required for customs clearance	7.1	7.2	7.3	7.4
	Time spent by cargo awaiting departure of next mode of transport (road or rail)	8.1	8.2	8.3	8.4
	Overall time of cargo in port	9.1	9.2	9.3	9.4
	Ship's capacity utilization	10.1	10.2	10.3	10.4
Information	Hinterland transportation modes' capacity utilization	11.1	11.2	11.3	11.4
	Security in information sharing	12.1	12.2	12.3	12.4
	Degree of Flexibility in using information technology	13.1	13.2	13.3	13.4
	Access speed to information	14.1	14.2	14.3	14.4

Accuracy of information regarding status of shipment	15.1	15.2	15.3	15.4
Provision of on-time updates of cargo information	16.1	16.2	16.3	16.4

Analysis

1.3 - Storing the freight billing in a tamper-proof manner would decrease the inaccuracy of freight billing and the chance to have contrasting information at a later stage of the process. Moreover, it would decrease the chance for the container to be stopped for customer clearance.

2.1– Blockchain could decrease the cost for cargo documentation transaction since the information should not go through a third party. The cheaper service would result in a larger utilization of the port community system.

2.2 - Process traceability would decrease the number of P2P communications to register a process step, which leads to a lower cost of communication.

2.4 - IoT and Smart contract lead to an automatization of the communications, decreasing the need for human intervention. The large amount of information provided by smart devices can be distributed in an automatized way.

3.4 – Including the container due date on the smart contract and communicating the container status through IoT, could enable a better arrangement of the supply chain in a way that demurrage and detention costs are reduced.

6.1 –Many delays on the process take place because the parties in charge of the cargo commercial release do not have a complete overview of the documentation. This is due to the fact that the consignee, who has access to the cargo information, does not share all the required information with the third party. However, having this information on the chain could enable this intermediary to gain access to the documentation.

6.3 – The communication between the third party, the ship agent and the external parties, such as banks and financial institutions, happen in a P2P manner and it is not automatized. Proving better and faster process information to the external party would be beneficial for the speed in the container commercial release.

6.4 – Delays in paying the invoices is one of the main reasons behind the waiting time for commercial release. When the vessel is sailing from Asia to Europe, there are on average one or two weeks for the consignee or freight forwarder, who works on behalf of the consignee, to send the payments for the cargo. Whether these payments could be automatized, the time required for commercial release would be near to zero.

7.1 – “The information sometimes is different between what the ATO declares and what the freight forwarder declares. The freight forwarder works on behalf of the consignee. The information is lost or it is manipulated in some way. Using blockchain to store the information and give to everyone access to this info could be a possible solution for the problem. The information is correct at the beginning of the chain and it has to be consistent. This incongruence between the info provided by the ship agent and the local freight forwarder is due to regular manipulations. The info gets lost along the chain since it moves from hand to hand.” Having the information unalterable and stored on the chain since the beginning, when

it is recorded, would decrease the customs block and, as a consequence, the time for customs clearance.

7.2 – Having a picture of the previous ports visited by the vessel or the stakeholder that handled the cargo could provide information to the customs in order to perform more accurate risk analysis.

8.1 – Having the cargo documentation in place allows the container to leave for the hinterland, this can be improved by providing a secure mean for storing and transacting cargo information. Therefore, providing a system that decreases the chances of contrasting or altered information could speed up the process of arranging the hinterland transportation.

8.2 – Making the process information available to every party involved in the process in order to increase the coordination and the hinterland transport planning, would decrease the time of a container awaiting for the hinterland transport.

8.4 – IoT of Things and Smart Contract could automatize the process of cargo transportation towards the hinterland by providing faster process information and automatizing steps of the process. Moreover, it could enable new business model and accuracy in the transport planning. Knowing the exact position of a container at the terminal, as well as during the transportation could increase the planning for the following steps in the process.

9.1 – 9.2 – 9.3 – 9.4 Are the results of what said in the previous points

11.2 – Providing faster information on the process steps as well as a planning of future information enables the organization of the hinterland transportation in a way that the capacity is fully exploited.

11.4 - In case smart contract implementation with process' deadlines connected to it, you could improve hinterland transportation because you know which container could still wait for a barge or for a road transportation and which one not. This information could be accessed in advance for a better planning of the hinterland transportation. The smart contracts contain deadlines for the cargo to be in a certain point at a certain time.

12.1 – The issue at stake consists in evaluating how are the parties who require the information access. Since blockchain is based on encryption and a secure access mechanism, the parties can trust the system and providing a larger amount of information. Moreover, the technology could enhance the consistency of the information to be hold unaltered along the chain.

12.2 – Like 12.1, the access to the information on the process could be given to the only parties requiring that information to perform certain tasks and not to gain a commercial advantage over the information provider. The increase security could encourage other parties to share information on the process that they already have, improving the overall process.

12.4 - IoT and Smart contract have operational benefits but they raise concerns regarding the security of the data registered.

15.1 – The documentation inaccuracy is one of the major issues that leads to delays in the process. For instance, the time required for customs clearance is enlarged by contrasting information on the cargo. Therefore, increasing the cargo information accuracy would improve the customs risk analysis and decrease the chances for a container to be stopped for customs checks.

15.3 – The accuracy of the information necessary for trade finance is sometimes lacking, since the invoices include a value that is sometimes different from the value shown on the cargo documentation. This inaccuracy lead to delays in the process and a slower lead-time.

16.1 – 16.2 - 16.4 Blockchain is not the most efficient way to transaction on-time information. However, the provision of process information that are already stored in some parties' database could increase the on-time availability of information. Moreover, the provision of information recorded through smart devices increases the availability of updates about the cargo. Similarly, the expansion of the network which leads to better coordination could provide some improvements on this matter.

Dutch Customs perspective

KPI		Cargo Documentation Transaction	Process Traceability	Trade Finance	IoT and Smart Contract Automatization
Financial	Freight bill Accuracy	1.1	1.2	1.3	1.4
	Overall Cost for the Information flow of a unit of cargo from the first to the last nodal point	2.1	2.2	2.3	2.4
	Average cost for detention/demurrage	3.1	3.2	3.3	3.4
Operational	Ship Turnaround time	4.1	4.2	4.3	4.4
	Road vehicle turnaround time	5.1	5.2	5.3	5.4
	Time spent by cargo awaiting commercial clearance	6.1	6.2	6.3	6.4
	Time required for customs clearance	7.1	7.2	7.3	7.4
	Time spent by cargo awaiting departure of next mode of transport (road or rail)	8.1	8.2	8.3	8.4
	Overall time of cargo in port	9.1	9.2	9.3	9.4
	Ship's capacity utilization	10.1	10.2	10.3	10.4
	Hinterland transportation modes' capacity utilization	11.1	11.2	11.3	11.4
	Security in information sharing	12.1	12.2	12.3	12.4
Information	Degree of Flexibility in using information technology	13.1	13.2	13.3	13.4
	Access speed to information	14.1	14.2	14.3	14.4
	Accuracy of information regarding status of shipment	15.1	15.2	15.3	15.4
	Provision of on-time updates of cargo information	16.1	16.2	16.3	16.4

Analysis

2.1 Much of the cargo documentation is printed on paper and several copies of the documents are generated. The time and work of the people to transact this information comes at a cost. If the documentation is stored on a chain, the different parties would retrieve it from the chain.

2.2 “In the supply chain there are several parties that earn money because of information asymmetries. If the coordination asymmetry is removed, this parties do not earn any money, since they do not add value to the physical flow. There is a lack of trust which make these parties survive.”

3.2 If the parties exchange more information on the process, there would be more coordination among the different organizations. This would speed up the commercial clearance and the hinterland transportation planning resulting in a faster process, which has less chance to incur in detention and demurrage costs.

6.3 If the banks are more connected to the system and they have visibility over the operational process, they would perform the payment in a faster way. This would result in a shorter time required for commercial release.

6.4 In case the communication of the container discharge is written on the chain through smart devices and the transaction is triggered by smart contracts, the communication could be faster and the payment automatized.

7.1 “However, it usually happen that different parties provide contrasting information on the cargo. Currently, the information about the cargo is uploaded by just one party in the supply chain. However, will implement the “Multiple filing”, every party in the supply chain needs to file the information that she has.” By storing the cargo documentation on the chain, the information consistency and accuracy could be preserved and each player that manages that information would have the same data on the cargo.

7.2 “To do that we need to know where the container is coming from and where it is directed to. If you look at supply chain visibility, the biggest part is related to supply chain traceability. Cargo information is really small and it is reality to the description of the good (i.e. socks). The information of the contents is not that interesting for us since it refers to something that is “said to contain”. “

“It is more interesting to evaluate where the ship is coming from, who is the recipient of the goods and similar information. Because this allow us to look for certain patterns when smuggling drugs. We use the information about the content.”

“The planning for entry is kept secret, since in this phase a lot of drug is smuggled. Since much drug or illegal transport is unloaded from the terminal in this phase, this planning is kept secret in order not to help smugglers in their actions.” So that the better coordination and the on-time accessibility of information is a key point in logistics.

8.2 An increase in process information transaction would enable a better visibility over the process steps, which results in a faster process and in an easier arrangement of the hinterland transportation.

8.4 “Internet of Things have a large potential in the future for the generation of a large amount of data and the automatization through smart contract, but it is more a long term solution. “

9.1 This effect is the result of a shorter time required for customs checks, which has an impact on the total process time.

9.2 A process visibility has the potential to improve customs clearance process, commercial clearance process and hinterland transportation planning. Therefore, it has an overall impact on the process total time.

9.3 “We would like in the future to keep the information for the insurance, in order to double proof the value of the cargo and make the taxation based on the value of the insurance and banks.” If the customs could talk directly with banks and insurances, they could get access to more reliable data for the calculation of taxes.

9.4 “Internet of Things have a large potential in the future for the generation of a large amount of data and the automatization through smart contract, but it is more a long term solution.”

12.1 Storing and transacting information via blockchain might decrease the chances for documentation of information manipulation. Moreover, it would give access to the information to the only parties that require them to perform their activities in the process.

12.2 The process information transaction via blockchain would lead to a stronger control of the access to information that could hamper the competitiveness of the people sharing them. Moreover, in order to prevent drugs smugglers to have visibility over process information, a blockchain solution might be more secure than others (i.e. Antwerp Information System Hacking Attack)

13.2 Some process information that are currently transacted via P2P means of communication might be stored on a blockchain solution and the access given to all the parties that need the information to perm their activities. This would result in less P2P communications.

13.4 IoT could introduce an automatize mechanism to the commination uploading described in the point 13.2.

14.1 If the cargo documentation is already stored in the blockchain since the port of departure, the transaction of this documentation is faster, since it has not to be uploaded in a centralized system (PCS) and then transacted to the several users.

15.1 Storing the cargo documentation on the chain since an early stage of the supply chain would prevent the data to be lost or manipulated along the chain. This might result in an enhanced accuracy.

16.2 The cargo information would be uploaded on the chain without going through a third party. This would result in an on-time availability of updates to all the different parties that needs that information on the process.

Digital services developer at Terminal

	KPI	Cargo Documentation Transaction	Process Traceability	Trade Finance	IoT and Smart Contract Automatization
Financial	Freight bill Accuracy	1.1	1.2	1.3	1.4
	Overall Cost for the Information flow of a unit of cargo from the first to the last nodal point	2.1	2.2	2.3	2.4

	Average cost for detention/demurrage	3.1	3.2	3.3	3.4
Operational	Ship Turnaround time	4.1	4.2	4.3	4.4
	Road vehicle turnaround time	5.1	5.2	5.3	5.4
	Time spent by cargo awaiting commercial clearance	6.1	6.2	6.3	6.4
	Time required for customs clearance	7.1	7.2	7.3	7.4
	Time spent by cargo awaiting departure of next mode of transport (road or rail)	8.1	8.2	8.3	8.4
	Overall time of cargo in port	9.1	9.2	9.3	9.4
	Ship's capacity utilization	10.1	10.2	10.3	10.4
	Hinterland transportation modes' capacity utilization	11.1	11.2	11.3	11.4
	Security in information sharing	12.1	12.2	12.3	12.4
Information	Degree of Flexibility in using information technology	13.1	13.2	13.3	13.4
	Access speed to information	14.1	14.2	14.3	14.4
	Accuracy of information regarding status of shipment	15.1	15.2	15.3	15.4
	Provision of on-time updates of cargo information	16.1	16.2	16.3	16.4

Analysis

1.2 “Freight billing, if we talk about the transportation billing, there are also involved storage days, detention and demurrage (logistics bills). A higher visibility over process information can be a more accurate information source in the billing process.”

2.2 The companies that are doing the transportation (truck companies) sometimes are connected to 18 different information systems from where they retrieve information. This redundancy of information systems is due to the specialization into different product transportation (fresh foods, normal containers) or they are developed by a company to get connected to the different parties.

3.2 The detention and demurrage might be decreased by a better coordination or transportation planning. If the releases are there right away, also the hinterland transportation can be arranged right away. Moreover, the same detention and demurrage can be avoided in case the container has a shorter process time.

5.2 Terminals could benefit from the information about the time and mode of container pickup, it could improve the stacking process as well as the in-time delivery of the container to the mode of transportation.

6.3 “Trade finance represents a good initial blockchain application in logistics since it is limited to a small amount of parties in the process. “I believe that the first blockchain application will be that one that requires as little connections as possible to all the different logistics parties for two reasons: they are too much separate from each other (for every supply chain you need a global solution); the technical maturity of the industry is really low. There are few people that know about the technological development in the industry.”

“For a general shipment, there is some point where the responsibility of the container goes from the shipper to the consignee. Sometimes it goes from the shipper to the consignee already at the port of origin. There are many potential responsibility transfers. In some of those the customs release needs to be provided by the consignee, but this can be done only when he receives the responsibility for the cargo, but this happen only when it is discharged. In that sense, the information is not available only after discharge. This can create delays in the problem.”

7.1 The customs clearance is not under the responsibility of the terminal. Therefore, I do not have much insight on it. However, I believe that having more accurate and consistent data would ameliorate the customs process.

7.2 Process Information could be an extra-source of information in the process of customs clearance.

8.2 “We are willing to share more information about the container process in exchange to information about the container mode and time of transportation. The most important information for the terminal is the expected time of arrival and the expected mode and time of hinterland transportation. We would like to know the mode of transportation before the arrival of the container which corresponds to the arrival of the vessel. Terminal is not interest in knowing what is inside the container for responsibility issues.”

9.1 Result of the customs clearance.

9.2 Result of the increased process visibility, and coordination over the hinterland transportation.

11.2 Hinterland transport can benefit from a better visibility over process information and on-time updates. On the other hand, the terminal could benefit from on-time information on hinterland transportation mode and time as soon as it is arranged.

12.1 Sometimes, cargo documentation is transacted via email or other means of communication that can be easily hacked or subject to human mistakes. A blockchain based on an encrypted mechanism might ensure a higher level security giving information access only to those who need it.

12.2 Similarly to 12.1, PIN code are sometimes transacted via email. This leave the chance to smugglers to interfere in the container pickup process.

14.1 – 14.2 - 14.3 – 14.4 An information stored on the blockchain might be easily retrieved compared to the process of asking to another party in the process for the information access.

15.1 Having the information stored on the chain by the party owning the information and since the initial stages of the chain, it could be an insurance of information accuracy.

16.1 - 16.2 - 16.3 - 16.4

“Some parties profit from inefficiencies. The value of all this blockchain technology is in the global supply chain. For whom is that interesting? for everyone that has a stake in the cargo, all the operators and service providers in between, they gain from inefficiencies. So there is a lot of information that is not available everywhere. I don't think that the barrier for blockchain is the lack of trust but the lack of understanding. Even if the different parties will distrust each others, if there is a good solution out there you would cooperate anyway because if they do not do it, there will be someone else doing it.”

Shipping Line

KPI		Cargo Documentation Transaction	Process Traceability	Trade Finance	IoT and Smart Contract Automatization
Financial	Freight bill Accuracy	1.1	1.2	1.3	1.4
	Overall Cost for the Information flow of a unit of cargo from the first to the last nodal point	2.1	2.2	2.3	2.4
	Average cost for detention/demurrage	3.1	3.2	3.3	3.4
Operational	Ship Turnaround time	4.1	4.2	4.3	4.4
	Road vehicle turnaround time	5.1	5.2	5.3	5.4
	Time spent by cargo awaiting commercial clearance	6.1	6.2	6.3	6.4
	Time required for customs clearance	7.1	7.2	7.3	7.4
	Time spent by cargo awaiting departure of next mode of transport (road or rail)	8.1	8.2	8.3	8.4
	Overall time of cargo in port	9.1	9.2	9.3	9.4
	Ship's capacity utilization	10.1	10.2	10.3	10.4
	Hinterland transportation modes' capacity utilization	11.1	11.2	11.3	11.4
	Security in information sharing	12.1	12.2	12.3	12.4
Information	Degree of Flexibility in using information technology	13.1	13.2	13.3	13.4
	Access speed to information	14.1	14.2	14.3	14.4
	Accuracy of information regarding status of shipment	15.1	15.2	15.3	15.4

Provision of on-time updates of cargo information	16.1	16.2	16.3	16.4
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Analysis

2.2 “Our shipping line is constantly working to automatize the flow of information in order to decrease the costs. While other shipping lines are still working on paper documentation. The big advancement took place when the company moved to automatic EDI information transactions. Phone calls and emails are already gone for sharing information. However, there is still room for further automatization and transaction of information that are currently not shared. “

5.1 While rail and barge planning is more accurate and the visits at the terminal are communicated large in advance. The truck scheduling has a shorter buffer, therefore it happens that sometimes delays happens because the truck enter the terminal but the container documentation is not in place.

5.2 “In the most automated terminals such as AWG, when a disruption occurs it is particularly difficult to find a solution. So having a better information and a higher accuracy of the data that are stored, would help in preventing disruption to happen and better answer to the events.”

5.4 The use of smart devices to communicate the container location and process status might increase the process visibility and it enables a better process planning.

6.3 “There are several players along the chain, whether a small player wants to arrange the all supply chain by itself, it is responsible for arranging the documentation in accordance to the local and specific regulation. Moreover, several carriers still work with paper documentation, which leads to make the process less automated. The commercial release is also dependent on the payment method. There are some methods that are straightforward while other delay the process of few days. Delays in commercial release occurs in merchant carries but not in deep-sea carrier. Because for merchants carriers, the end customers is responsible for the transportation in the hinterland. In deep-sea carrier, the shipping line is responsible for the door-to-door transportation, while in merchant carrier, it is responsible just for the deep-sea side. When this change in responsibility takes place, there might be problems of communication. “

6.4 The commercial release is dependent on the time the payment is performed. This transaction can be automatized with smart contracts and triggered by information written on the chain.

7.1 The accuracy of the documentation since the first phases of the supply chain and the consistency all over the chain represent a fundamental pre-requisite for decreasing the time required for customs clearance and insure the security of import process.

7.2 “The list of previous ports visited by the vessel is already known by the shipping line, at least concerning our shipping line. this is one of the reasons why we do not encounter so many problems with customs. However, sometimes it is also a matter of providing information to customs in the format that they require.”

Customs still wants trackers to have physical paper on their hands. In this way, process-wise the information sharing can be speeded up. However, However the entire documentation of the cargo cannot be shared easily with everyone. It cannot happen that the commercial value of the good is easily shared with everyone.”

8.2 “Once the cargo is unloaded from a cargo vessel, the carrier does not know whether that container will be picked up by barge, train or rail. Providing this time of information, while reduce the delays. However, this imply that the consigner, who is in a different corner of the world, knows in advance the mode of transportation.”

9.1 It is the result of the accuracy and consistency of data.

9.2 “The lack of trust and information spread represent one of the big challenge for hinterland blockchain. People do not trust each other and are not willing to share information that might affect the company's competitiveness. Despite the market is expanding, the margins are really limited so every time I spread information, I have to be very conscious on the type of information and the content. It is difficult to differentiate between commercial and operational information. “

11.2 “There are new projects that want to combine barge appointments between terminal in Rotterdam. However sometimes the commercial information is not protected. I'm expecting from a blockchain solution that all the parties will be put on the same level, otherwise it is not a fair implementation. If the flow of information is not regulated a party can always over rule.”

“They have less cranes than the number of barges they are serving. The process delays generate a domino effect on the hinterland transportation modes, which prevent the full capacity to be ensured. This terminal congestion implies that the barge cannot discharge all the containers for the export, which prevent the barges from load other containers.”

12.1 “A blockchain system might increase the security of information, but it needs the development of a very fair agreement among the parties.” The technological solution has to be designed in such a way that it prevent commercial information spill over and opportunistic behavior from the organizations joining the platform.

12.2 The encrypted mechanism itself is not sufficient to convince the parties in sharing a larger amount of information. Despite many companies are aware of the benefits that such a solution might provide, they do not trust the other parties in the process.

13.2 There are many information systems in which information is stored and transacted. They communicate with each other being connecting through EDI connection. However, whenever you have a system interface, there is a percentage of error and it is not 100% accurate. Having a unique repository for process information would be beneficial for the entire process.

14.1 Being stored on the chain since an early stage of the process, the information can be easily accessible by querying the system rather than an external party.

15.1 The information accuracy is ensured since the party that records such an information is the one that generates it. The optimal solution is the one in which there are not intermediaries between the information owner and the one that generate the documentation, who, in this case, is the one that records it onto the ledger.

16.1 - 16.2 - 16.3 Similarly to the information access speed, updates can be accessed on-time since the access can be given to different parties, who can retrieve the information as soon as it is retrieved.

“Blockchain is not the solution, it is a way to a goal. A new way of doing business. Therefore, it should not be applied to solve old processes.