Using Blockchain to Sustainably Manage Containers in International Shipping

Completed Research Paper

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Abstract

This paper investigates how blockchain technology can improve information flows on empty container repositioning at an inter-organizational level in the shipping industry. By adopting a theory-generating design science research approach, we develop and evaluate an industry-wide blockchain artefact, named Greenbox Platform, where container owners can register, trade and share containers. It brings efficiency for shipping companies via cost reduction through minimizing the need for empty container repositioning, and effectiveness for leasing companies via container proof of ownership. The paper contributes to its application domain by a practical, theory-driven and novel application of blockchain technology to the shipping industry. Theorizing on its development and evaluation, the paper provides preliminary groundwork for two nascent design principles: 1) Explicitly define a structure of incentives for interorganizational and cross-industrial blockchain applications where stakeholders' interests are not necessarily aligned; and 2) Consider environmental sustainability as a non-functional requirement in the development of a blockchain artefact.

Keywords: Blockchain, shipping industry, DLT systems, design science research

Introduction

Container shipping forms the backbone of our globalized economy. The industry's scale and reach were made possible to a large extent by the introduction of standardized containers, which drove down the cost of international shipping and created a highly competitive industry (Feibert, Hansen, and Jacobsen 2017). Containerized cargo represents the most common way to transport general goods (Stopford 2009; Notteboom 2004; Midoro, Musso, and Parola 2005) and these goods' right-time and right-place availability is crucial for global trade (Stopford 2009; Kocak 2015). Empty container repositioning is one of the most pressing issues in the container shipping industry, as shipping empty containers is both costly and has significant environmental and sustainability impacts. Moving empty containers is directly related to fuel consumption, congestion, and emissions (Song and Dong 2015). Drewry Shipping Consultants have estimated that about 20% of all ocean container movements involve repositioning, while simulation results have shown that repositioning of empties may account for up to as much as 27% of the total container fleet running cost, or as many as 26 million empty container moves annually (Mongelluzzo 2004; Song et al. 2005). However, if shipping and leasing companies were to pool management of and access to containers, costly repositioning could be minimized; companies could use whatever container was closest rather than moving empties around. Such a pooling of containers requires a reliable and trustworthy platform that seamlessly optimizes available container capacity.

Traditionally, there has been no single system for container coordination among global trade partners. Electronic data interchange has been utilized to manage information flows, but these systems did not account for many critical issues, making industry-wide digital coordination unfeasible (Jensen, Bjørn-Andersen, and Vatrapu 2014). According to Nærland et al. (2017), a true global information infrastructure would increase efficiency in the industry (Jensen, Bjørn-Andersen, and Vatrapu 2014). Such an infrastructure could be based on the new type of distributed databases known as blockchain (Peters and Panayi 2015), which potentially minimize security risks while providing a "single source of truth" (Beck, Müller-Bloch, and King 2018; Zheng et al. 2016). However, blockchain technologies are not widely understood and lack a solid common knowledge base (Glaser 2017), and they are also subject to technical challenges and limitations (Yli-Huumo et al. 2016). In this study, we explore how blockchain technologies can enable process improvements in the container shipping industry. By doing so, we respond to calls for research into digitalization in the shipping industry (Fruth and Teuteberg 2017; Betz and Henningsson 2016). We also contribute to the limited but growing knowledge base concerning blockchain technologies (Glaser 2017), while providing a practical and theory-driven use case for blockchain technologies beyond cryptocurrencies (Risius and Spohrer 2017).

In order to investigate how blockchain technology can improve container-related information flows in the shipping industry, we built and evaluated a blockchain-based prototype for registering and sharing containers. Our research combines a design science approach with grounded theory methods (Beck, Weber and Gregory 2013); our aim is not to follow any kernel theory but to derive nascent theoretical insights through design science research. Our study of the problem, and the development, evaluation, and theorizing of our blockchain artefact, were guided by the research question:

How can blockchain technology improve information flows on empty container repositioning at an inter-organizational level in the shipping industry?

In the following we will illustrate how blockchain can potentially be used to prove container ownership as well as to create a platform for sharing containers. Our research process also provides a theoretical contribution in the form of preliminary groundwork for two nascent design principles that may be useful in future applications of blockchain technology in cross-industry settings. In the following pages, we provide an overview of relevant literature within the container shipping industry as well as related blockchain research. Then, we introduce our applied design science methodology and present our research steps in building and evaluating our blockchain artefact, the Greenbox Platform. The main body of our analysis presents the Greenbox Platform. Subsequently we discuss our findings and reflect on their implications for future research.

Literature Background

Blockchain Technology

After the first application of blockchain technology in the form of Bitcoin (Nakamoto 2008), and the subsequent emergence of freely programmable blockchains with Ethereum, research interest in blockchain expanded rapidly (Yli-Huumo et al. 2016). A blockchain is a distributed ledger technology (DLT), secured by cryptography and governed by a consensus mechanism (Beck et al. 2017, 1). Peters and Panayi (2015) defined the blockchain as a "new type of distributed database" (Peters and Panayi 2015, 8–9), where the integrity of data is maintained across all nodes (Yli-Huumo et al. 2016; Glaser 2017) by "storing a consistent, immutable, linear event of transactions between networked actors" (Risius and Spohrer 2017, 386). Nodes are linked by a peer-to-peer (P2P) network (Glaser 2017; Beck and Müller-Bloch 2017), where transactions are sent directly from one party to another without a third party acting as an intermediary (Nakamoto 2008). Environments are typically classified along two dimensions: 1) access to transactions, which can be public or private, and 2) access to transaction validation, which can be permissioned or permissionless

(Nærland et al. 2017). Even though blockchain has been referred to as a "radical" or "ground-breaking" innovation (Beck and Müller-Bloch 2017), it does not come without limitations. Some researchers have noted that "blockchain components and its properties are hard to grasp in detail" and that there is a "lack of a solid common knowledge base, especially in information systems" (Glaser 2017, 1543). Others have pointed out technical challenges and limitations for blockchain, especially in relation to scalability, latency, size, security, and wasted resources (Yli-Huumo et al. 2016). However, several scholars have argued that issues such as scalability can be dealt with by using permissioned environments (Peters and Panayi 2015; Vukolić 2017).

Every node in the blockchain network has an identical replica of the blockchain's transaction history, and nodes reach consensus on the validity of transactions and add new blocks to the chain based on different possible mechanisms (Nærland et al. 2017; Christidis and Devetsikiotis 2016). At the time of writing, the three main consensus mechanisms are proof-of-work (PoW), proof-of-stake (PoS) and proof-of-authority (PoA) (Zheng et al. 2016; Li et al. 2017; X. Xu et al. 2017; Christidis and Devetsikiotis 2016; Beck, Müller-Bloch, and King 2018). PoW is the mechanism used to generate new blocks in the Bitcoin blockchain (Nærland et al. 2017). As explained by Christidis and Devetsikiotis (2016), Bitcoin nodes compete to perform the complex computation that validates each block in the chain, a process called Bitcoin mining. The node that wins the competition is rewarded with cryptocurrency by the system (Beck, Müller-Bloch, and King 2018; Zheng et al. 2016). PoS typically gives nodes with more cryptocurrency, i.e. those with a greater stake, a greater chance of validating the next block (Beck, Müller-Bloch, and King 2018; Yuan and Wang 2016). In contrast to the other mechanisms, in PoA the individual (or institution) behind the node needs to be known (Eklund and Beck 2019; Zheng et al. 2016; Vukolić 2016). Since participants are selected by a governing body (Vukolić 2016), there is no risk of a single entity subverting the network by creating multiple identities, and there is no need to incentivize validation with cryptocurrency rewards (Christidis and Devetsikiotis 2016). In PoA consensus, pre-selected participants agree on transactions through voting (Liu et al. 2019; Baird 2016).

Blockchain in the Maritime Shipping Industry

Blockchain applications have been attempted in the shipping industry already (Nærland et al. 2017). Due to the many stakeholders involved as well as the need for integrated information flows across different countries, supply chains and shipping processes are regarded as suitable areas for blockchain applications. Gausdal, Czachorowski and Solesvik (2018) developed a framework for blockchain applications within the maritime industry given current barriers to and drivers of digital innovation. The main driver is cost reduction, which can be achieved with blockchain because "it is impossible to counterfeit transactions in blockchain," which "makes it possible to reduce a company's costs related to financial control" (Gausdal, Czachorowski, and Solesvik 2018, 7). Another driver of blockchain adoption is the industry's interest in "pursuing eco-friendly goals, such as … 'green' technologies and a 'green' supply chain" (Gausdal, Czachorowski, and Solesvik 2018, 2). Czachorowski, Solesvik, and Kondratenko (2019) suggested that blockchain should be used to reduce pollution in the maritime industry and help companies comply with increasing regulations. Besides cutting transportation costs and supporting "green" policies, blockchain eliminates the cost of duplicated documents and quality control standards (Gausdal, Czachorowski, and Solesvik 2018, 7). Pedersen, Risius, and Beck (2019, 101) noted that document duplication leads to "incoherent and dispersed data storage systems" and proposed a ten-step "blockchain decision path" based on a prototype ship registry they created in collaboration with the Danish Maritime Authority. Much interest in applying blockchain to the maritime shipping industry stems from the need for a common shared database among multiple parties with low levels of mutual trust. Another promising application for blockchain in the shipping industry is in handling trade finance or logistics-oriented documents such as bills of lading. Shipping documentation is currently handled by multiple incompatible systems, meaning that documents often must be entered manually (Korpela, Hallikas, and Dahlberg 2017). Nærland et al. (2017) addressed this issue by putting shipping documentation on blockchain smart contracts.

Container Shipping Industry

Container shipping is a vital part of the maritime logistics industry, but containers do not move exclusively within the maritime industry. Increasingly, shipping companies manage the shipping process from end to end, which requires holistic coordination on land and on sea (Stopford 2009). In other words, the shipping supply chain comprises not just large maritime shipping companies, which mainly operate container vessels, but also port operators and freight forwarders (Stopford 2009, 512; Kocak 2015). Other actors, such as governmental authorities, are also part of the chain even though they do not undertake the actual shipping (Jensen, Bjørn-Andersen, and Vatrapu 2014).

Containers were introduced to the shipping supply chain to automate transport processes, and a wide range of standardized container types were developed, including open-top, ventilated, integral reefer, insulated reefer, tank and so on (Stopford 2009, 511). Containers have an average life of 12–16 years (Stopford 2009) and are mainly purchased by shipping companies and container leasing companies (Theofanis and Boile 2009; Notteboom 2004). While shipping companies operate containers as a means of transporting goods, container leasing companies consider the containers themselves their core asset, which leads to a complex interaction between the two actors (Theofanis and Boile 2009).

Since maritime logistics and shipping is a highly competitive market, industry actors are always trying to improve their supply chain performance. Recent efforts have included technologies such as container radio-frequency identification (RFID); real-time tracking of cargo through Global Positioning System (GPS) signal; and optical character recognition (OCR) to scan documents (Heilig and Voss 2017). Companies have also made extended use of digital services (Feibert, Hansen, and Jacobsen 2017; Gausdal, Czachorowski, and Solesvik 2018) and used real-time data to reduce delays and increase transparency (Fruth and Teuteberg 2017; Haraldson 2015). Betz and Henningsson (2016) showed how a container security device (CSD) providing GPS data about containers via satellite can lead to efficiency increases on the company as well as the supply chain level (Betz and Henningsson 2016). Additional benefits of CSD include fewer stolen containers, more efficient container stacking on vessels, and reduced costs for empty container repositioning (Betz and Henningsson 2016). These proposed solutions are not mutually exclusive and may complement one another. Yet, there has been no indication that these initiatives have eliminated the problem of empty container repositioning. According to Song and Carter, "the percentage of empty movements out of total container movements is 21.46%, 25.05%, 26.38%, 27.12%, and 27.98% for the years 2003–2007 respectively" (Song and Carter 2009, 15).

Qualitative Research and Design Science Methodology

Theorizing from Design Science

In this research we merge a design science research approach with grounded theory techniques (Beck, Weber and Gregory 2013). Unlike other qualitative methods, the combination of grounded theory methods and design science research (DSR) allows for a continuous interplay between data collection, artefact development, and analysis (Urquhart, Lehmann and Myers 2009). In our approach, grounded theory techniques are not only used to develop an initial understanding of the problem and to generate potential solutions, but are also applied in combination with DSR elements in iterative cycles of "simultaneous problem solving and theory generation" (Beck, Weber, and Gregory 2013, 638).

We defined our research lens by exploring issues in empty container repositioning at an inter-organizational level, and we generated initial solutions for these issues through iterative cycles of theoretical sampling, collection, and data analysis (Beck, Weber, and Gregory 2013). Next, we systematically collected and analyzed a range of data, including results from our stakeholder analysis, raw and coded interview data, extant literature, and other information; we used these data to guide the formulation of our solution proposal, tentative design, and requirements. This iterative process, in which we repeatedly reassessed data in light of new insights from the design research, ultimately informed solution and design proposals tailored to meet the requirements of the container shipping sector. The development and evaluation of the artefact formed a foundation for further theorizing. The theory-generating step we applied is an extension of Kuechler and Vaishnavai's process (2008; 2012), which "enables additional theoretical insights, beyond the developed IT artefact and therefore represents an intertwined process of problem solving and theorizing" (Beck, Weber, and Gregory 2013, 643). To widen our understanding of container repositioning at an inter-organizational level, this research project has been conducted in cooperation with Blockshipping, a start-up that is developing a Global Shared Container Platform (GSCP) to optimize the management of containers in the shipping industry. Typically, information systems (IS) artefacts are implemented within a single organization to improve its effectiveness and efficiency (Hevner et al. 2004). However, blockchain projects usually aim for a community or industry-wide implementation, making it imperative to investigate the perspectives of many different stakeholders. Grounded theory methods are especially important here, as they allow "an in-depth understanding of the problem space and its environmental factors" (Beck, Weber, and Gregory 2013, 639) and provide a structured approach to analyzing multiple perspectives. The inter-organizational setting of our research requires a thorough stakeholder analysis from the outset. In our research, listing and mapping stakeholders involved several iteration cycles. We conducted nine semi-structured interviews with partners from different stakeholder groups (see Table 1). The interviews were transcribed and subsequently coded for alternative forms of analysis (Walsham 2006) using grounded theory method techniques (Urquhart, Lehmann, and Myers 2009). Several key topics emerged from the initial interviews, including current processes, information flows, container tracking, potential process improvements, information sharing, and governance, and these early findings helped us to refine our interview questions and decide who to interview next.

Based on the interview coding, we developed the technical requirements for our artefact (Sommerville 2011). There were six key requirements: 1) identification requirements, which "specify whether or not a system should identify its users before interacting with them"; 2) authentication requirements, which "specify how users are identified"; 3) authorization requirements, which "specify the privileges and access permissions of identified users"; 4) non-repudiation requirements, which "specify that a party in a transaction cannot deny its involvement in that transaction"; 5) integrity requirements, which "specify how data corruption can be avoided"; and 6) privacy requirements, which "specify how data privacy is to be maintained" (Sommerville 2011, 330).

Interview	Stakeholder	Job title	Research label	Interview
1	Shipping company	Chief product owner for digital department	Shipping company A	37:30
2	Blockshipping	CEO and CTO	Blockshipping	54:19
3	Shipping company	Manager digital solutions	Shipping company B	58:58
4	Consultancy	Consultant in containers financing	Consultancy	01:04:41
5	Trade union	Business development for digital department	Trade union	38:27
6	Container standards	Chairman of container standards firm	Standard provider	58:09
7	Authority	Head of data and business development	Authority	59:03
8	Port terminal	Digital business solutions	Port	48:57
9	Container leasing	Industry expert from leasing company	Leaser	No record

Table 1. Conducted Interviews

Evaluating IT artefacts is crucial in theory-generating DSR, as it provides robustness and generates new knowledge about the problem for further developments (Venable, Pries-Heje, and Baskerville 2016; Beck, Weber, and Gregory 2013; Kuechler and Vaishnavi 2008). In our evaluation we were inspired by the Framework for Evaluating in Design Science (FEDS) developed by Venable, Pries-Heje and Baskerville (2016), which enables design science researchers "to effectively design and incorporate evaluation activities into a DSR project that can achieve DSR goals and objectives" (Venable, Pries-Heje, and Baskerville 2016, 1). Our evaluation comprised four episodes, which we conducted in two phases (see Table 2). The first phase was mainly formative, while the second phase was mainly summative. Both phases were conducted with Blockshipping and a shipping company. Shipping companies were a key player in our project and a targeted user of the blockchain artefact, hence we consider their feedback crucial.

Phase	Purpose	Episode	Company	Date
1	Mostly formative with summative elements	1	Blockshipping	24/05/2019
		2	Shipping company B	28/05/2019
2	Mostly summative with formative elements	3	Blockshipping	01/07/2019
		4	Shipping company B	05/07/2019

Table 2. Evaluation Episodes

The first evaluation episode consisted of a workshop with Blockshipping executive managers and included a presentation of the blockchain artefact, followed by a discussion. Participant feedback was incorporated into the next iteration of the blockchain artefact. The second evaluation episode was conducted via video call with the Manager of Digital Solutions at one of the shipping companies interviewed in the data collection phase (Shipping company B). Here again, the evaluation was mostly formative and the feedback was incorporated into the development of the blockchain artefact. The last two evaluation episodes, which were mostly summative, were conducted via video calls with the same interviewees. After discussing the actions taken to improve the artefact, the interviewees from both Blockshipping and Shipping company B assessed whether the blockchain artefact successfully addresses the problems identified and, thus, provides an improvement.

Analysis of the Qualitative Data

We identified seven categories of major selective codes: industry status, container processes, tracking and sensors, blockchain design requirements, opinions on prospect of blockchain, data input, and container sharing (see Figure 1). These seven categories each comprise several layers of grouped codes. In total, there are 80 different codes: 7 major selective codes and 73 subsidiary codes. These codes are built from 237 unique references.

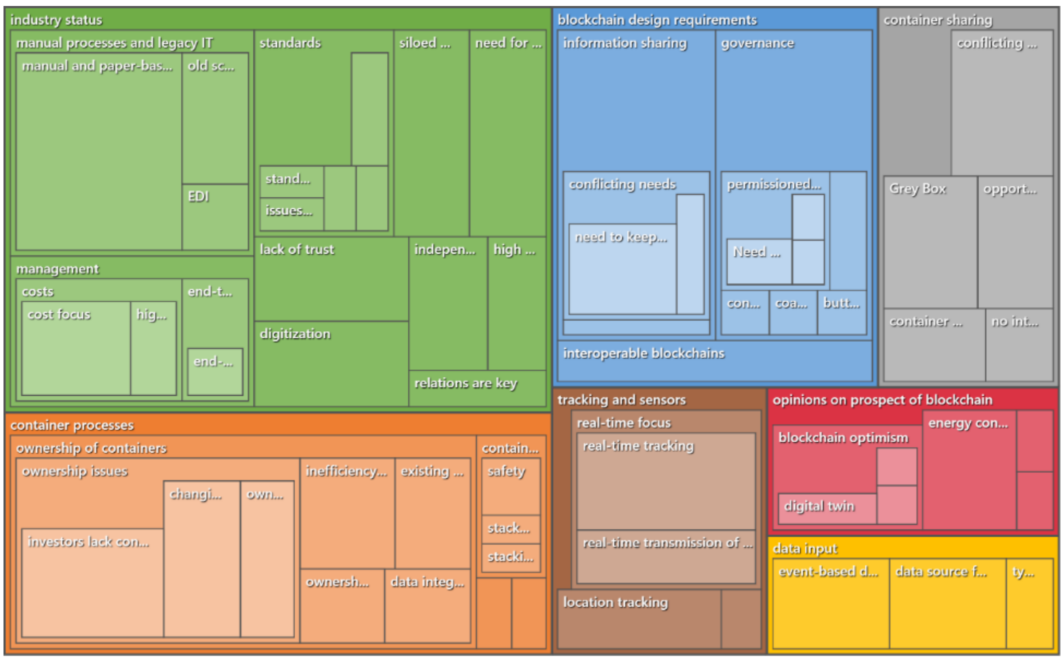

Figure 1. Hierarchy of Codes

Two selective codes are noteworthy due to their amount of references. First, the selective code "manual and paper-based processes"' which has 15 references split on 7 interviews. Second, the selective code "ownership issues" has 25 references split on 5 interviews. This finding led us to explore these topics further. However, we should note that our interview questions were tailored towards container-related processes, which means code references referring to topics we were probing during interviews are likely overrepresented. For instance, the relatively large number of references to "ownership issues" does not necessarily indicate that this code should be considered more important than others. Instead, the number of references is but one indicator in a multistep qualitative sense-making endeavor that also considers the extant literature and other slices of data.

In the next step, we built theory codes, which are "inferential and/or predictive statements" (Urquhart, Lehmann, and Myers 2009, 367). These codes are about container-related processes in the shipping industry, and about blockchain technologies' fit in the same context. A total of 14 theory codes were developed iteratively throughout the project. Compared to the previous coding steps, this step put greater weight on data outside of the interviews, in particular the extant literature.

These theory codes represent predictive statements about problems in the shipping industry. Based on these codes, we propose a blockchain-based platform, called Greenbox Platform, to address the identified problems. The main reason to adopt a blockchain-based solution in the shipping industry is to mitigate trust issues, as blockchain maintains the integrity of transaction data.

Shipping industry perspective	**Shipping company perspective**	**Leasing firm perspective**
• Lack of trust among actors • Inefficient manual processes • Lack of common standards • Widespread data silos • Processes changing because of environmental focus • Intense industry-wide competition	• Lack of real-time container tracking • General wish for predicting container movements • Empty container repositioning • Unwillingness to share commercial information • Unwillingness to use containers if they have competitors' logo on them	• Lack of methods for proving container ownership • Unwillingness to create efficiency for shipping companies • Unwillingness to share commercial information

Table 3. Grouped Theory Codes, Organized by Industry Perspective

Besides being subject to blockchain's fundamentals, such as having an immutable ledger shared in a peer-to-peer network, the core features of the platform as derived from the qualitative research include a) a global shared container register for container owners, b) a trading service to buy and sell containers in the secondhand market, c) a way to securely prove ownership of a container, and d) a matching service allowing shipping companies to share containers instead of repositioning them empty. The functional requirements of the Greenbox Platform are outlined in Table 4. According to Sommerville (2011), "these are statements of services the system should provide, how the system should react to particular inputs, and how the system should behave in particular situations."

F1	*General system requirement*: The system shall allow users to register • The system shall require the user to input user information (company name, user name, job title, country, email) • The system shall send an email when registration has been processed
F2	*General system requirement*: The system shall require users to log in
F3	*General system requirement*: The system shall allow users to register a container and edit container information • The system shall require the user to input container data (container-prefix, -number, -type, -logo) • The system shall require the user to upload ownership documentation (bill of sale, container insurance) • The system shall allow the user to register and edit container information in batches
F4	*Blockchain network requirement*: The system shall allow users to check status of any container • The system shall return a status of verified or unverified ownership • The system shall provide a history of container ownership
F5	*Smart contract requirement*: The system shall allow a user to transfer the ownership of a container to another user • The system shall allow the user to pick containers from a list of its registered containers • The system shall allow the user to transfer selected registered containers to another user account
F6	*Both general and blockchain requirement*: The system shall allow the user to supply containers • The system shall require the user to pick from a list of its registered and verified containers • The system shall require the user to input availability data (pickup and drop-off, container type, time period, logo) • The system shall allow the user to whitelist other users from seeing the supplied containers • The system shall allow the user to supply containers in batches
F7	*Both general and blockchain requirement*: The system shall allow the user to search for available containers • The system shall require the user to apply filters (pickup and dropoff location, container type, time period, logo) • The system shall show a list of registered and verified containers by applied filters • The system shall allow the user to search for containers in batches

Table 4. Functional User Requirements

In addition, our research identified several non-functional requirements of the Greenbox Platform, outlined in Table 5: these are constraints on the services or functions offered by the system.

NF1	*Identification:* The system shall require a permissioning authority (Blockshipping) to grant users access to the system before they can interact with other users
NF2	*Authentication:* The system shall allow the permissioning authority to identify the users, who shall upload the container's bill of sale and insurance documentation
NF3	*Authorization:* The system shall allow to specify the privileges and access permissions of identified users in a permissions file
NF4	*Non-repudiation:* The system shall allow the implementation of smart contracts so that a party in a transaction cannot deny its involvement in that transaction
NF5	*Integrity:* The system shall implement blockchain technology to avoid data corruption by adding transactions to an immutable ledger shared across participants
NF6	*Privacy:* The system shall specify how data privacy is to be maintained, especially regarding commercially sensitive information such as GPS location of containers
NF7	*Throughput:* The system shall handle 3,000 transactions per second
NF8	*Data storage:* The system shall store transactional data on-chain and raw data related to containers and participants off-chain. Off-chain data shall be assigned to on-chain transactions via hash-based keys

Table 5. Non-functional System Requirements

The platform provides services mainly for two user groups, namely shipping companies and container leasing companies, as they are the main container operators in the shipping industry. The suggested platform and its underlying requirements are based on the insights from the coded interviews, extant literature and feedbacks from evaluation.

Development of the Blockchain Artefact

The Greenbox Platform

In this section, we explain how the blockchain-based Greenbox Platform works to fulfill the functional requirements illustrated in Table 4. After creating an account, users can log into the system with their credentials and register their containers. Once a container is registered, it can be traded among container operators. A container operator wishing to supply containers whitelists other container operators so that they can find and use the available containers. The operator then provides information on the type of container, locations for container pick-up and drop-off, and the period of availability. Thus, information about container location, time availability, type, logo, prefix and number are open only to whitelisted users.

System Architecture

We next explain the development of the artefact itself. Following the non-functional requirements specification and inspired by Xu et al's (2017) design framework, we used a structured '"decision path" to decide which blockchain to use and how to design its architecture. According to our empirical data, and in line with extant literature, this environment should be both permissioned and public. Permissioned blockchains are appropriate for regulated industries (X. Xu et al. 2017), where whitelisting procedures are used to identify participating users (this approach is also used in digital representations of titles of ownership (Peters and Panayi 2015, 6)). The environment should also be public, so that all participants in the network can read and submit transactions, as this solution is designed to operate not within a single organization, but across the industry. Thus, we cover the non-functional requirement for identification (NF1) because users must be given permission to interact with the system; we also cover the non-functional requirement for authorization (NF3) because users' privileges and access permission are specified in a permissions file.

With a permissioned public setting, every node is known to the network, making Proof of Authority the preferred consensus mechanism, and we suggest that one node should correspond to one vote. This choice covers the non-functional requirement for identification (NF1). As a consensus mechanism, PoA has the additional advantage of being more environmentally sustainable than some other mechanisms. The decision to build a permissioned public blockchain using PoA consensus made Hyperledger Fabric, a permissioned platform allowing for modular consensus mechanisms, the platform of choice (Androulaki et al. 2018; Gorenflo et al. 2019). Hyperledger Fabric can handle more than 3,000 transactions per second, which is enough for our blockchain artefact at this initial phase. The design of the blockchain's system architecture depends on the level of decentralization and on data storage. In our test case, the blockchain artefact is initially centralized: the Greenbox Platform acts as the only permissioning authority, and the governing body operating Greenbox gives permission to join the network (NF1), verify users' documentation (NF2), specify users' permissions (NF3) and define how data privacy should be maintained (NF6). However, having a shipping industry stakeholder in the role of permissioning authority was seen as a barrier to the technology's adoption.

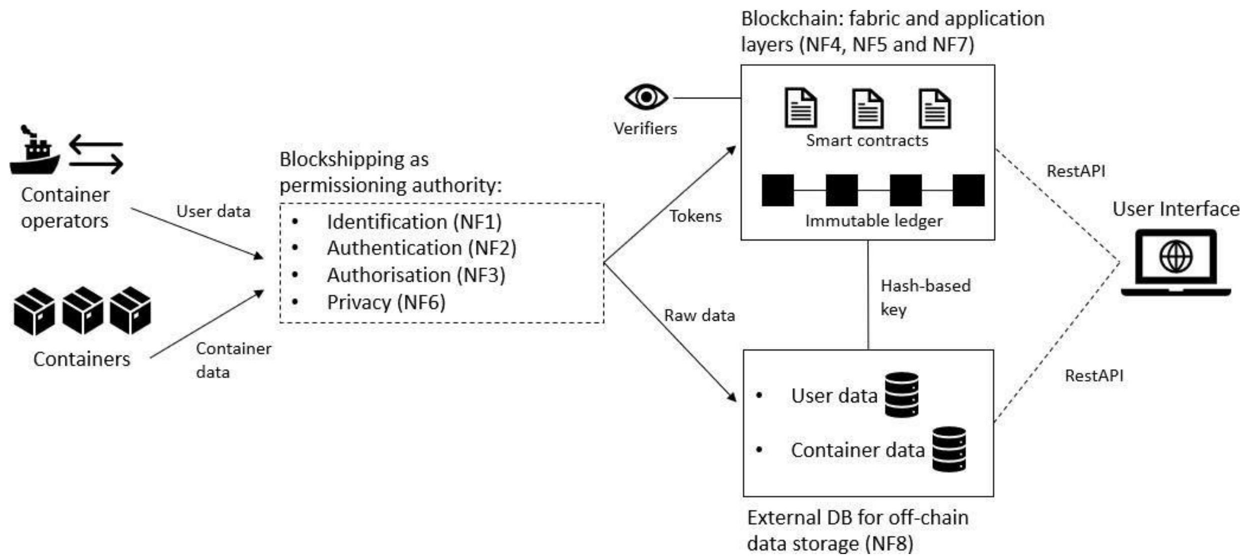

Figure 2. Blockchain Artefact System Architecture

Therefore, we recommend that Blockshipping, as an entity without a direct stake in the shipping industry, act as permissioning authority. We also recommend that in later stages this role be taken on by a governance board composed of industry leaders (a strategy also recommended by our interviewee from Shipping company B, who noted the importance of allowing industry leaders to define new standards for the use of blockchain technology in shipping). Blockshipping envisions this group of industry leaders being represented by the Digital Container Shipping Association (DCSA), which Blockshipping expects will include a wide range of industry actors in addition to shipping companies. The other key element affecting design of the system architecture is data storage. We decided to store on-chain only data vital to transactions, such as the unique identification number for each container and information about when a container is traded or changes its owner. Other data, such as other master data related to containers and users, are stored off-chain.

Figure 2 shows data as 1) user data from container operators, e.g., a shipping company's name and country; and 2) container data, including a container's identification number and weight. User and container data are permissioned by Blockshipping, which decides whether a user can join the network or a container's documentation is valid and then issues a "token" or unique identifier. The "tokenized" container and the "tokenized" user enter the blockchain, while raw data referring to the user and container are stored in an external database. Some of the data that enter the blockchain may require verifications from authorities or standard providers acting as verifying nodes.

Smart Contracts

In our DSR artefact, created on Hyperledger Fabric, the smart contracts were written on Hyperledger Composer, which allows development of quick proof of concept blockchain applications. As an illustration of Greenbox Platform's capabilities, we wrote a smart contract to track container ownership in secondhand container trading. This illustration includes a model file, where we specify that our assets are represented by containers and list the attributes of each, and a script file containing the logic of the smart contract.

The model file belongs to the org.blockshipping.network and defines containers as assets. In our example, containers have six attributes: containerToken, which is the key that uniquely identifies a container; prefix, a four character identifier showing the current owner; number, which is based on ISO standards; type (e.g. dry, reefer, ventilated); logo, which indicates whether a container has a logo on it and whether that logo belongs to a shipping company or to a container leasing company; and TareWeight, the container's unladen weight. (In our model, TareWeight serves as an example of a technical detail to include as a container attribute; other technical details can be included.) The participants, or Traders, are uniquely identified by a tradeId and have a company attribute. Similarly, each Container is identified by the attributes listed above. A Trade takes place when Container and Trader participate in a transaction. The Trade class has an attribute called amount, which represents the price of a container. When a Trade transaction takes place, the function changes the prefix of the Container traded from that of the original Owner to that of the new Owner. The Container is then updated in the containerRegistry with the new Owner's information. The smart contract is event-triggered and subject to blockchain technology's fundamentals, and as a result it covers the requirement for non-repudiation (NF4): each participant to the network that is involved in container change of ownership is subject to the smart contract and cannot deny involvement. Both the extant literature on blockchain and our empirical interview data confirm the usefulness of smart contracts. As an interview respondent said, "[…] the lease of a container just moves over from one partner to another, and everything is just set in stone" (Interview: Shipping company B).

Secondhand Container Trading

We focus on this specific process because our findings indicate that secondhand trade of containers currently has inefficiencies. A consultant we interviewed said, "The thing here is that it's not difficult when you buy a container from the manufacturer, but it becomes difficult when you sell the container. That is the tricky part" (Interview: Consultancy). In addition, many activities in the process for trading containers secondhand are conducted by hand, in what the interviewee described as "a very manual [process]" (Interview: Consultancy). The blockchain-enabled process starts when a prospective buyer places an order for containers with a seller. (In Figure 3, the seller is represented by Container Lease A/S and the buyer by CPH Shipping company.) The buyer checks the container status by evaluating information such as the history of ownership, bills of sale, and other technical specifications available in the Greenbox Platform on blockchain. If the buyer is satisfied with the check they buy the container; if not, the order details are re-negotiated. If the container is bought, a transfer of ownership is registered on the blockchain (by editing the container ownership prefix) and the containers are put into use by the new owner.

In the Greenbox-enabled system, documents for the container status check are no longer handled manually, which greatly streamlines the process. In addition, the container information is now placed in an immutable ledger. The initial owner is required to provide quality documentation, but only once: the initial owner enters this information when registering the container in the blockchain, rather than owners providing and transferring documents at each trade. The new owner does not need to re-enter information about the container, since the blockchain artefact acts as a shared database.

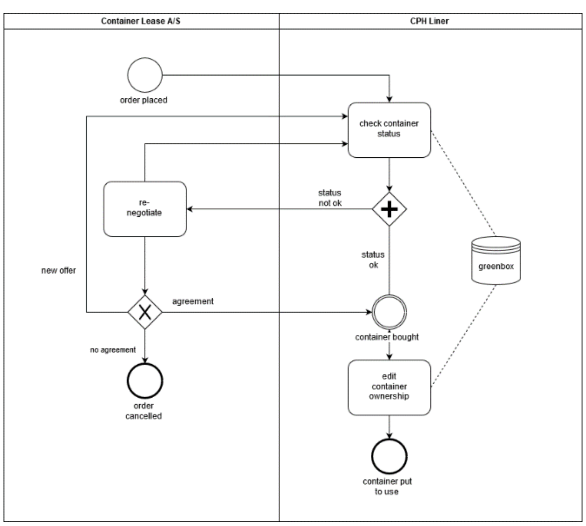

Figure 3. Secondhand Trading

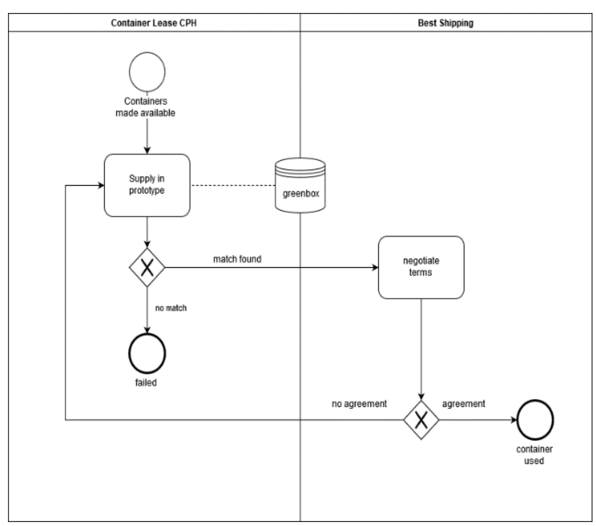

Figure 4. Container Matching for Leasing

Matching Containers for Lease

The process of matching containers for lease is illustrated in Figure 4. When containers are made available for lease, typically by a leasing company (Container Lease CPH), the leasing company marks the containers as available in the Greenbox Platform. If an interested customer (Best Shipping), or match, is found through the Greenbox Platform, the two parties negotiate terms. If terms are agreed upon, the containers are used by the customer. The Greenbox Platform makes the search for matches more efficient, because the blockchain allows leasing companies to choose how widely to share information: only with trusted companies or with all nodes in the network. This makes it possible for a company to share only with its usual trusted companies or to locate previously unknown customers. In addition, companies wishing to lease containers no longer have to check container status and can narrow their search to only the type of container sought. In addition, documentation provided about the containers is integrated into the blockchain, removing the delay caused by email and phone inquiries and enhancing trust among all parties.

Incentive Structure

The shipping literature has identified a lack of coordinated action among multiple stakeholders as an obstacle. Therefore, we define an incentive structure for using a shared platform like Greenbox. Here, incentives represent a tool to "overcome diverging goals" among multiple stakeholders (Beck, Müller-Bloch, and King 2018, 13). Both our empirical data from interviews and the literature point out that shipping companies are concerned with cost reduction: "[…] cost is the big word here: if you put cost cutting on the top of your list, then you have already attention" (Interview: Shipping company B). One way to cut costs is to share containers that otherwise would be repositioned empty. As one interviewee put it: "Which is the main cost of [the] container transportation industry? The empty container!" (Interview: Standard provider). The blockchain artefact allows container leasing companies to register container assets on-chain, where container ownership is tracked. This prevents the same container from being sold several times to different buyers because blockchain technology, unlike paper-based documents, prevents such duplication. Every time a container changes owner a smart contract appends that transaction to the blockchain ledger, which is immutable. Therefore, this allows shipping companies to reduce costs by increasing efficiency, while giving leasing companies an effective way to prove their container assets.

Evaluation of the Artefact

After developing the blockchain artefact, we evaluated it with two interviewees from Blockshipping and a shipping company. Several actions emerging from this evaluation episode are illustrated in Table 6.

The general feedback was positive. Interviewees who evaluated the blockchain artefact generally agreed that the Greenbox Platform addresses the identified problems. The interviewees positively assessed the platform's focus on environmental sustainability: they cited the name "Greenbox" and the development of a theoretical test-case structure populated with real-world data as "smart thinking" (Interview: Shipping company B, Evaluation Episode #4). Moreover, the interviewees recognized that although environmental sustainability historically has not been a powerful motivator for industry action, sharing containers would reduce the need to reposition empty containers and increase asset security for leasing companies.

From a technological perspective, the functionalities, the design of the blockchain architecture and the smart contract examples found positive feedback. The only concern was related to storing data off-chain because "as soon as data [go] off-chain, the whole question about who owns the data comes up again" (Interview: Shipping company B, Evaluation Episode #4). Moreover, if the proposed solution adopts Hyperledger Fabric, our respondent observed, then "we basically decided […] to join the forces of Hyperledger Fabric" (Interview: Blockshipping, Evaluation Episode #3).

Evaluand	Blockshipping	Shipping company B	Actions
Functional requirements and user interface	• *Whitelisting preferred over blacklisting* • *Registering containers requires bill of sale and insurance documentation*	• *Whitelisting preferred over blacklisting* • *Container search function should include container type* • *Allow "batch" option to register, trade, supply and book multiple containers*	• *Replace blacklisting with whitelisting* • *Add container type as data input* • *Add batch functionality* • *Add bill of sale and insurance documentation as data input*
Non-functional requirements and system architecture	• *Track CO2 emissions on each container*	• *Information on container location should be private* • *Information on a single container's CO2 emissions should be private, aggregated number public*	• *Add immutable log to track CO2 emissions on each container, but only aggregated number shall be public* • *Allow privacy for GPS location of containers*
Smart contract	• *Validated*	• *Validated*	• *No actions required*
Process mapping	• *Need more detail on what container status means*	• *Shipping companies unlikely to act as suppliers in as-is process of container matching*	• *Add more details on container status in the process description* • *Change supplier from a shipping company to a leasing company in container matching process*
Incentive structure	• *Market trending towards 100% containers owned by leasing companies* • *Public pressure for environmental sustainability*	• *Shipping companies unwilling to use containers with competitors' logo* • *Public pressure for environmental sustainability*	• *Flag the logo as functional requirement and in UI* • *Create new incentive for leasers based on potential container market share increase* • *Create new incentive for carbon emissions reduction to the industry and add it as a non-functional requirement*

Table 6. Evaluation of the Blockchain Artefact and Subsequent Actions

Discussion of Empirical Findings

Nascent Design Principle 1: Define Incentives

Explicitly define a structure of incentives for interorganizational and cross-industrial blockchain applications where stakeholders' interests are not necessarily aligned.

When studying the application of IT in the shipping industry, Betz and Henningsson (2016) suggested further research on how to improve coordination on an inter-organizational level among different stakeholders. Simultaneously, studies on blockchain technologies in the shipping industry have identified "the need to move beyond looking at only one domain and one company" (Nærland et al. 2017, 13), and DSR scholars have discussed the importance of the researcher-client relationship (Iivari 2015). However, we have not found concrete research strategies in the literature on what expanding from a single-company to a multiple-actor approach, or a single-client to a multiple-client approach, requires from researchers. Thus, this research asked how blockchain can improve information flows on empty container repositioning at an inter-organizational level in the shipping industry and identified different interests and incentives at play that potentially can be addressed by the Greenbox Platform.

Our qualitative research found that an improvement in efficiency for one organization did not necessarily translate into an improvement for another. This was especially the case for the two main container-owning stakeholder groups, shipping companies and container leasing companies. Shipping companies, for whom repositioning empty containers is a major cost, were primarily interested in improvements in predicting container movements. Leasing companies, whose business model in part depends on shipping companies' inability to predict container movements, were less interested in improving shipping companies' operational efficiency, since increased efficiency and reduced repositioning could put their business model under pressure. Although this is a conflict, even under an improved system shipping companies would still rely on container leasing companies to provide flexibility and to reduce their total cost of container ownership. These different incentives in the market need to be considered and engineered into the Greenbox Platform. Such complexities and conflicting priorities are not uncommon when building blockchain solutions in other cross-industry and multiple-actor settings. Our findings lay the preliminary groundwork for a nascent design principle: that incentives must be defined in a way that accommodates the decentralized and multi-organizational environment in which many blockchain solutions take shape. Furthermore, it seems that future DSR studies of blockchain technologies in cross-industry settings will benefit from a more structured approach to developing incentives.

We recommend that future research develop a framework for identifying and mapping incentive mechanisms and structures that is generic enough to be used as a lens in many different industries. This may include looking into how incentives can be modeled and (if necessary) re-engineered in DSR as a grounding for autonomous incentive reconciliation mechanisms and related information systems research. A great deal has been written about blockchain and trust, but appropriate incentive structures are equally important for functioning autonomous blockchain-based markets.

Nascent Design Principle 2: Address Environmental Sustainability

Consider environmental sustainability as a non-functional requirement in the development of a blockchain artefact.

The repositioning of containers is not only an economically costly problem, but also raises the question of how sustainable and eco-efficient it is. Our study revealed that environmental sustainability is gaining importance in the container shipping industry, not only because of regulatory demands and related coercive pressure, but also because the public increasingly rejects fuel intensive global shipping operations if they can be avoided. In our research, we found that environmental focus is changing processes in the container shipping industry. Thus, it became imperative to address environmental sustainability in the artefact development, if the solution was to have relevance in the future. Therefore, we included environmental sustainability as a non-functional requirement for the engineering of the blockchain artefact.

The shipping industry is already seeking eco-friendlier ways to operate logistics using the latest technology (Gausdal, Czachorowski, and Solesvik 2018; Kocak 2015). Our research contributes to this goal as the Greenbox Platform can help reduce emissions and improve the environmental sustainability of international logistics and shipping. Our results do not quantify the Greenbox Platform's potential emission reduction, as this depends on adoption rate and on future design choices. Nonetheless, since empty container repositioning may involve as many as 26 million empty container moves annually (Song et al. 2005), even low adoption rates can potentially reduce empty repositioning by hundreds of thousands of moves. Our findings related to environmental focus are relevant to the industry in general, rather than specifically to blockchain solutions. This suggests that environmental sustainability should be considered not only in the development of blockchain artefacts, but should be a general requirement for DSR relating to information systems in shipping. However, our study only provides an initial indication, and more empirical work should be conducted in order to test this claim.

Based on our findings, we call for further research on the interplay between the demand for environmental sustainability and the development of new technologies. Our data indicate that the public increasingly demands environmental sustainability, but precisely how it can be achieved is still under-researched. We ask for further research in this area to determine factors influencing sustainability. One approach could be through the use of the PESTEL matrix in information systems research, where political, economic, social, technological, economic and legal dimensions are considered (Fruth and Teuteberg 2017). Fruth and Teuteberg (2017) offered an example of the application of PESTEL in the shipping industry to identify external influences in relation to digitalization. This research might provide a structured approach to including environmental sustainability in future studies and in other industries.

Positioning the Solution Type

According to Gregor and Hevner's (2013) DSR knowledge contribution framework, DSR research contributions are categorized based on the maturity of the application domain, which represents the maturity of the problem context and of the solution developed for that problem. We followed this framework in discussing the technology maturity and the context of the industry we focus on. We argue that our project represents an improvement, as "the goal of DSR in the improvement quadrant is to create better solutions in the form of more efficient and effective products, processes, services, technologies, or ideas" (Gregor and Hevner 2013, 346). This raises the question of how challenges presented by introducing a new technology to a conservative industry, such as the maritime shipping industry, can be researched to create better solutions. According to Gausdal, Czachorowski and Solesvik (2018), the conservative culture of the shipping industry might inhibit its adoption of blockchain, even though Greenbox Platform addresses the fundamental issue of trust by relocating trust from the industry to the technology. On the one hand, since these actors do not trust each other, they might embrace blockchain as a means of guaranteeing the integrity of transaction data. On the other hand, industry actors might be as reluctant to trust a new technology as they are to trust each other. However, other drivers such as cost reduction may help minimize this barrier, and interviewees did consider cost reduction a clear incentive for using the Greenbox Platform. In short, our findings paradoxically indicate that a strong conservatism coexists with a willingness to investigate new technical solutions. It would be interesting for further research to study the interplays and dynamics of innovating to understand how an otherwise very conservative industry is willing to take the lead in investigating cutting edge technologies and their application.

Conclusion

In this research, we applied a theory-generating DSR approach to develop a blockchain-based artefact that improves processes in the shipping industry. In so doing, our work contributes to the research on blockchain technologies by applying blockchain beyond the cryptocurrency domain. We have been able to develop functional and non-functional requirements in our empirical coding process and we have identified diverging incentives and interests that need to be aligned in order to realize a blockchain-based platform for container management. Thus, we provide some nascent insights into the role of incentives and how they might be recognized and embedded in DSR when developing inter-organizational systems. Moreover, our research contributes to the shipping industry domain itself by explaining how digitalization can lead to process improvements, both in terms of efficiency and effectiveness, for different actors in the industry.

To answer our research question, we developed a blockchain artefact, called Greenbox Platform, that allows container owners in the shipping industry to register, trade, and share their containers. Greenbox Platform was proposed, developed, and evaluated as a solution to a set of problems identified in the industry: inefficient manual processes, lack of trust among actors, fragmented data, and need for more environmental focus. We developed a system architecture that satisfies the non-functional requirements uncovered by our research. We acknowledge two main limitations in this research study. First, even though we ideated, developed, and evaluated a blockchain artefact, our Greenbox Platform has not yet been implemented and adopted in the real world. In the context of this study, implementation and adoption should be understood as the platform being populated by users' data. When the platform is adopted in real-world contexts, new practical and theoretical insights may emerge, and we recommend further research based on those insights to improve the platform. Second, the empirical data gathered for this research might be subject to bias. It is possible that our project description led contacted organizations to point us towards interviewees with an interest in blockchain technology. While preexisting interest in and knowledge about blockchain technology in itself does not present a problem, some interviewees may have had an interest in promoting such technology, and interviewees with an undefined, or less positive, view of the technology may have been underrepresented. Despite this limitation, we consider this study as a valid starting point for further research in the application of blockchain in the shipping industry.

Besides contributing to blockchain and shipping domain literature, we provide preliminary groundwork for two nascent design principles relevant to future applications of blockchain technology. First, we propose defining an explicit structure of incentives for cross-industry blockchain applications where stakeholders' interests are not necessarily aligned. This nascent design principle contributes to the theoretical framing of the research: It suggests that when developing a blockchain artefact for use by multiple organizations, improvements in efficiency and effectiveness are achieved by incentivizing the actors involved to coordinate their actions. We recommend that the DSR methodology develop and incorporate methods for defining incentives, especially when developing artefacts for more than one organization.

Finally, we recommend that environmental sustainability be considered a non-functional requirement in the development of blockchain artefacts—that sustainability be incorporated into the architecture of such artefacts. Extant literature in the shipping industry highlights the need for industry actors to pursue eco-friendly goals. This, combined with the increasing societal pressure for "greener" policies confirmed empirically in this research, leads us to propose including environmental sustainability as a nascent design principle. Environmental sustainability will continue to gain importance, which will only increase the need for more and smarter solutions.

References

Andersen, J. V., Ingram Bogusz, C. 2019. "Self-Organising in Blockchain Infrastructures: Generativity through Shifting Objectives and Forking," *Journal of the Association for Information Systems* (20:9), 247-265.

Androulaki, E., Manevich, Y., Muralidharan, S., Murthy, C., Nguyen, B., Sethi, M., Singh, G. 2018. "Hyperledger Fabric: A Distributed Operating System for Permissioned Blockchains," in *Proceedings of the Thirteenth EuroSys Conference on Computer Systems - EuroSys'18*, 1–15. Porto.

Beck, R. 2018. "Beyond Bitcoin: The Rise of Blockchain World," *Computer* (51:2), pp. 54-58.

Beck, R., Avital, M., Rossi, M., Thatcher, J. B. 2017. "Blockchain Technology in Business and Information Systems Research," *Business & Information Systems Engineering* (59:6), pp. 381-384.

Beck, R., Müller-Bloch, C. 2017. "Blockchain as Radical Innovation: A Framework for Engaging with Distributed Ledgers," in *Proceedings of the 50th Hawaii International Conference on System Sciences*. Waikoloa Village.

Beck, R., Müller-Bloch, C., King, J. L. 2018. "Governance in the Blockchain Economy: A Framework and Research Agenda," *Journal of the Association for Information Systems* (19:10) 1020–1034.

Beck, R., Weber, S., Gregory, R. W. 2013. "Theory-Generating Design Science Research," *Information Systems Frontiers* (15:4), pp 637-651.

Betz, M., Henningsson, S. 2016. "An Approach for Assessing the Benefits of IT Investments in Global Supply Chains," in *Proceedings of the 24th European Conference on Information Systems* Istanbul, Turkey.

Czachorowski, K., Solesvik, M., Kondratenko, Y. 2019. "The Application of Blockchain Technology in the Maritime Industry," in *Green IT Engineering: Social, Business and Industrial Applications*, pp. 561-577. Cham: Springer.

Eklund, P. W., & Beck, R. 2019. "Factors that Impact Blockchain Scalability," in *Proceedings of the 11th International Conference on Management of Digital EcoSystems* (pp. 126-133).

Feibert, D. C., Hansen, M. S., Jacobsen, P. 2017. "An Integrated Process and Digitalization Perspective on the Shipping Supply Chain - A Literature Review," in *2017 IEEE International Conference on Industrial Engineering and Engineering Management* (IEEM), pp. 1352-1356.

Fruth, M., Teuteberg, F. 2017. "Digitization in Maritime Logistics—What Is There and What Is Missing?," *Cogent Business & Management* (4:1), 1411066.

Gausdal, A. H., Czachorowski, K. V., Solesvik, M. Z. 2018. "Applying Blockchain Technology: Evidence from Norwegian Companies," *Sustainability* (10:6), pp. 1-16.

Glaser, F. 2017. "Pervasive Decentralisation of Digital Infrastructures: A Framework for Blockchain Enabled System and Use Case Analysis," in *Proceedings of the 50th Hawaii International Conference on System Sciences*, Waikoloa Village, Hawaii.

Gorenflo, C., Lee, S., Golab, L., Keshav, S. 2019. "FastFabric: Scaling Hyperledger Fabric to 20,000 Transactions per Second," *ArXiv*:1901.00910 [Cs].

Gregor, S., Hevner, A. 2013. "Positioning and Presenting Design Science Research for Maximum Impact," *MIS Quarterly* (37:2), pp. 337-355.

Güven-Koçak, S. 2015. "Maritime Informatics Framework and Literature Survey – EcosystemPerspective," in *Proceedings of the 21st Americas Conference on Information Systems*. Puerto Rico.

Haraldson, S. 2015. "Digitalization of Sea Transports – Enabling Sustainable Multi-Modal Transports," in *Proceedings of the 21st Americas Conference on Information Systems*. Puerto Rico.

Heilig, L., Voss, S. 2017. "Status Quo and Innovative Approaches for Maritime Logistics in the Age of Digitalization: A Guest Editors' Introduction," *Information Technology and Management* (18:3), pp. 175-177.

Hevner, A. R., March, S. T., Park, J., & Ram, S. 2004. "Design Science in Information Systems Research," *MIS Quarterly* (28:1), pp. 75-105.

Iivari, J. 2015. "Distinguishing and Contrasting Two Strategies for Design Science Research," *European Journal of Information Systems* (24:1), pp. 107–115.

Jensen, T-, Bjørn-Andersen, N., Vatrapu, R. 2014. "Avocados Crossing Borders: The Missing Common Information Infrastructure for International Trade," in *Proceedings of the 5th ACM International Conference on Collaboration across Boundaries: Culture, Distance & Technology* - CABS '14, pp. 15–24. Kyoto.

Korpela, K., Hallikas, J., Dahlberg, T. 2017. "Digital Supply Chain Transformation toward Blockchain Integration," in *Proceedings of the 50th Hawaii International Conference on System Sciences*, Waikoloa Village, Hawaii.

Kuechler, W., Vaishnavi, V. 2008. "On Theory Development in Design Science Research: Anatomy of a Research Project," *European Journal of Information Systems* (17:5), pp. 489-504.

Kuechler, W., Vaishnavi, V. 2012. "A Framework for Theory Development in Design Science Research: Multiple Perspectives," *Journal of the Association of Information Systems* (13:6), pp. 395–423.

Mongelluzzo, B. 2004. "Thinking inside the box", *The Journal of Commerce* (5:2), pp. 10-12.

Midoro, R., Musso, E., Parola, F. 2005. "Maritime Liner Shipping and the Stevedoring Industry: Market Structure and Competition Strategies," *Maritime Policy & Management* (32 :2), pp. 89-106.

Nærland, K., Müller-Bloch, C., Beck, R., Palmund, S. 2017. "Blockchain to Rule the Waves – Nascent Design Principles for Reducing Risk and Uncertainty in Decentralized Environments," in *Proceedings of the 38th International Conference on Information Systems* (ICIS), Soul, South Korea.

Nakamoto, S. 2008. "Bitcoin: A Peer-to-Peer Electronic Cash System," http://www.bitcoin.org/bitcoin.pdf

Notteboom, T. E. 2004. "Container Shipping and Ports: An Overview," *Review of Network Economics* (3:2), pp. 86-106.

Pedersen, A. B., Risius, M., Beck, R. 2019. "A Ten-Step Decision Path to Determine When to Use Blockchain Technologies," *MIS Quarterly Executive* (18:2), pp. 99-115.

Peters, G. W., Panayi, E. 2015. "Understanding Modern Banking Ledgers through Blockchain Technologies: Future of Transaction Processing and Smart Contracts on the Internet of Money," ArXiv:1511.05740 [Cs].

Risius, M., Spohrer, K. 2017. "A Blockchain Research Framework: What We (Don't) Know, Where We Go from Here, and How We Will Get There," *Business & Information Systems Engineering* (59:6), pp. 385-409.

Sommerville, I. 2011. *Software Engineering,* 9th ed. Boston: Pearson.

Song, D. P., Carter J. 2009. "Empty container repositioning in liner shipping," in Maritime Policy & Management (36:4), pp. 291-307.

Song, D. P., Dong, J. X. 2015. "Empty Container Repositioning," in *Handbook of Ocean Container Transport Logistics,* pp. 163-208. Cham: Springer.

Song, D. P., Marshall, J. A. R., Polak, J. W., Schumacher, K. 2005. "On cost-efficiency of the global container shipping network," in *Maritime Policy & Management* (32:1), pp. 15-30.

Stopford, M. 2009. *Maritime Economics*, 3rd ed. London: Routledge.

Theofanis, S., Boile, M. 2009. "Empty Marine Container Logistics: Facts, Issues and Management Strategies," *GeoJournal* (74:1), pp. 51-65.

Urquhart, C., Lehmann, H., Myers, M. D. 2009. "Putting the 'Theory' Back into Grounded Theory: Guidelines for Grounded Theory Studies in Information Systems: Guidelines for Grounded Theory Studies in Information Systems," *Information Systems Journal* (20:4), pp. 357-381.

Venable, J., Pries-Heje, J., Baskerville, R. 2016. "FEDS: A Framework for Evaluation in Design Science Research," *European Journal of Information Systems* (25:1), pp. 77-89.

Vukolić, M. 2017. "Rethinking Permissioned Blockchains," in *Proceedings of the ACM Workshop on Blockchain, Cryptocurrencies and Contracts* - BCC '17, 3–7. Abu Dhabi.

Walsham, G. 2006. "Doing Interpretive Research," *European Journal of Information Systems* (15:3), pp. 320–330.

Xu, J. J. 2016. "Are Blockchains Immune to All Malicious Attacks?" *Financial Innovation* (2:1), pp. 1-9.

Xu, X., Weber, I., Staples, M., Zhu, L., Bosch, J., Bass, L., Pautasso, C., Rimba, P. 2017. "A Taxonomy of Blockchain-Based Systems for Architecture Design," in *2017 IEEE International Conference on Software Architecture* (ICSA), pp. 243–252. Gothenburg.

Yli-Huumo, J.,Ko, D., Choi, S., Park, S., Smolander, K. 2016. "Where Is Current Research on Blockchain Technology? — A Systematic Review," *PLoS one* (11:10).

Zhao, J. L., Fan, S., Yan, J. 2016. "Overview of Business Innovations and Research Opportunities in Blockchain and Introduction to the Special Issue," *Financial Innovation* (2:1), pp. 1-7.

Zheng, Z., Xie, S., Dai, H., Chen, X., Wang, H. 2016. "Blockchain Challenges and Opportunities: A Survey," *International Journal of Web and Grid Services* (14:4), pp. 352-375.