SMART CONTRACTS FOR ENTREPRENEURIAL COLLABORATION IN LOGISTICS NETWORKS

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Abstract. Smart contracts are transactional scripts on the top of the blockchain technology that are created for executing and enforcing legal contracts. Self-executable they check contractual pre-defined conditions and automatically fulfil respective actions or transactions, respectively. Through this form of automation, the layers of middlemen can be reduced or even completely replaced. Accordingly, smart contracts bear the potential to decrease transaction and enforcement costs. In addition to this narrow obvious characteristic, we argue that smart contracts encase the potential to foster entrepreneurial collaborations of cross-organisational business processes and enabling trans-national networks of entrepreneurs and SMEs to enter into new business sectors which are currently still closed due to high entry barriers or to domination of big players. Especially, the logistics sector is well-known for dominating global players that try to limit entrepreneurial activities of small companies by using closed organisational structures and dedicated IT systems. The foundation and the organisational support for entrepreneurial collaborations in such logistics-related networks can be realised by the implementation of decentralized autonomous organisations based on blockchain technology and smart contracting. Accordingly, this paper discusses the research question how smart contracting and blockchain technology can facilitate the implementation of collaborative business structures for sustainable trans-national entrepreneurial activities in logistics networks. Our research is based on expert interviews, surveys and case studies from several EU projects with a focus on the ongoing project "Connect2SmallPorts". The research results will showcase and assess this potential of using smart contracting in the case of charter-parties.

Key words: *Entrepreneurial Collaboration, Smart Contracts, Blockchain, Logistics Networks*

JEL code: M16, O31, O33

Introduction

The presence of networks of materials flow in conjunction with information networks lead to the emergence of logistics networks that are typically distributed and decentralised (Ghiani et al., 2013). A logistics network, as defined by Liedtke and Friedrich (2012), on the micro- or meso-logistics level is the central decision-objects of an entity (e.g. firm or company), which represents a set of nodes (e.g. warehouses or transhipment spots) and transport connections; whereby logistics networks can differ from physical transport networks or links that are available to stimulate mobility demand of the entire economy (macro-logistics level). They are directly or indirectly interconnected and interlinked with other networks and tend to change their structure over time. In the latter case, for instance, the policy decisions about the inclusion of new EU-member states led next to new freight transportation, enhanced quantities and changed quality of cargo, in addition, to novel collaborations, products and actors as well as allocations in value adding logistics networks (Haasis, 2008). Similar as supply chains, logistics networks encase among other things suppliers, warehouses, distribution centres, retail outlets, raw materials, goods-in-process stocks and finished products (Simchi et al., 2000). Intermodal logistics networks are integrated transportation systems with at least two different transport modes, which are linked by terminals that ensure the modal shift (Haasis, 2008). Within logistics networks, the business performance is dependent from various agents, processes and product diversity (Gleissner & Femerling, 2013). Accordingly, they face characteristics like network complexity, time challenges, various customer needs, finite capabilities and resources, as well as security and safety requirements (Chandra and Kamrani, 2004; Haasis, 2008; Haasis and Szafera, 2005).

As a response to this, nowadays, the logistics related research efforts rise to develop potential reorganisations for a transition from scattered supply chains to open logistics networks where resources are accessible, compatible and interlinked (Rusich, 2017). Accordingly, supply chain management (SCM) challenges become smarter, more networked and fragmented as well as distributed (Prause, 2015; Olaniyi & Reidolf, 2015). This transition process in particular refers to Logistics 4.0 – also known as smart logistics – which is regarded as a specific management approach for developing, designing, managing and realising change-oriented networks of object flows (e.g. goods, information, values) based on pattern recognition, generalisation and self-organisation, enabled through the usage of new technologies and innovative services (Wehberg, 2015). A new and promising approach is based on blockchain technology and smart contracts.

Smart contracts are transactional protocols or scripts, respectively, on the top of the blockchain technology that are created for executing and enforcing legal contracts. Self-executable they check contractual pre-defined conditions and fulfil respective actions or transactions, respectively. Through this, the layers of intermediaries can be reduced or even completely replaced. Accordingly, smart contracts bear the potential to reduce transaction and enforcement costs and they bear the potential to foster entrepreneurial collaborations of cross-organisational business processes and enabling trans-national networks of entrepreneurs and SMEs to enter into new business sectors which are currently still closed due to high entry barriers or to domination of big players (Prause & Hunke, 2014; Prause & Hoffmann, 2017). The authors participate in several EU projects related to transnational entrepreneurship, regional development and service networks in the context of green logistics and sustainable supply chain management. As a result, scientific studies have shown that in the context of Industry 4.0, especially small and medium-sized enterprises can profit (e.g. Prause & Atari, 2017; Gerlitz, 2015 & 2017). This paper discusses the research question how smart contracting and blockchain technology can facilitate the implementation of collaborative business structures for sustainable trans-national entrepreneurial activities in logistics networks. To address this issue, we use the case of a simplified charter-party contract process with a single voyager in the freight market, and show the arising benefits of an appropriate technology implementation. The research is based on expert interviews, surveys and case studies from several EU projects with a focus on the ongoing project "Connect2SmallPorts", which investigates the digitalisation of small and medium-sized ports in Southern Baltic Sea Region. The research results will show that smart contracts are especially value adding for smaller and entrepreneurial actors, since their competiveness and efficiency may be improved and participation facilitated through the enabling adoption of this new technology due to the shared value that arise from the exclusion of intermediaries.

The present study is organised as follow: The subsequent section describes briefly the theoretical background of the blockchain and smart contract technology. Afterwards, the methodology is presented, followed by the research results and discussion chapter. The paper ends with a conclusion inclusive some limitations and implications for future research.

Theoretical Background

The blockchain technology – in its first stage of development – was designed by the scientist Satoshi Nakamoto in 2008 with the objective to generate digital coins whose control is distributed under the independent participating actors (i.e. decentralised) in a global virtual network, instead of a central institution (e.g. government or bank) with high bureaucracies, whereby the related preliminary first field of application – the cryptocurrency Bitcoin – became fully operational in January 2009 with the first successfully completed mining operation (Fridgen et al., 2018; Nakamoto, 2008; Pinna et al., 2018; Swan, 2015). Therefore, blockchains have their origins in the financial sector. They are regarded as open and decentralised ledger systems and allow participants or users via address account (i.e. alphanumerical code) and private key to process quickly transactions with each other in specific cryptocurrencies without a third party (e.g. intermediary, middleman, broker or agent), which leads to a decentralised network of trust (Chuen, 2015; Gallay et al., 2017; Liao & Wang, 2018; Manski, 2016; Swan, 2015). According to the provided distributed ledger or database, all participants have a copy and are allowed to contribute without repudiation, which replaces paperwork and potentially physical signatures. This decentralised character of blockchains can facilitate smaller, independent users' (e.g. entrepreneurs and SMEs) competitiveness and efficiency enabled through the improved information accessibility, reduced risks and layers of middlemen, and thus declining intermediary and transaction costs (Wu, 2018). Hence, this technology bears the potential to foster entrepreneurial collaborations in logistics networks across international borders. Generally, blockchains – as global shared networks or infrastructures – are differentiated into public and private, as well as permission-less and permissioned ones. A public blockchain – which is generally permission-less – is open for everyone (very often: anonymous participants), whereas a private blockchain network is accessible only for specific participants that are usually known. In a permission-less blockchain all users – also known as nodes – are allowed to mine, while in a permissioned blockchain this right to act as a minor is exclusively available for certain participants, whereby the access – similar to a private blockchain – is regulated (Fridgen et al., 2018; Kouhizadeh & Sarkis, 2018). Next to the decentralised network character, the term blockchain refers to a data structure, an ordered sequence of blocks – each containing data about a variable number of validated transactions – that are cryptographically chained (i.e. one by one) by the inclusion of the respective hash values and cryptographic signatures, which makes it impossible to amend a former already validated and integrated block of the chain without network members consensus (García-Bañuelos et al., 2017; Lansiti & Lakhani, 2017; Pinna et al., 2018). This unique data structure is permanently visible (i.e. transparent), verifiable and stored among a network of machines (e.g. computers), whereby each machine that dispose a full replica is a so-called full node (García-Bañuelos et al., 2017). Each network participant can verify and add new transactions to blocks (Wang & Liu, 2015), but afterwards this newest block needs to be validated by the minors, that are some of the full-nodes in proof-of-work blockchains like Bitcoin and Ethereum (García-Bañuelos et al., 2017). This validation procedure or creation of new blocks is called mining and poses a process, where the minors in the peer-to-peer network try to solve a computationally hard problem of determining a hash key for the new block, which then incorporate next to the transaction data (or any kind of information) among other things a timestamp, the respective hash code of the previous block, its height (associated progressive number) as well as the IP address of the first minor that has validated the new block (Pinna et al., 2018). As in a competition the winner takes it all, here the first minor who created the block receives a reward in form of new crypto-coins (Wang & Liu, 2015) and the transaction fees of all consolidated transactions (García-Bañuelos et al., 2017). Before the proposed new block is attached to the entire already existing chain of blocks, the full nodes check the consensuses via a mechanism or the validity of the created block, respectively (Kouhizadeh & Sarkis, 2018; Pinna et al., 2018). For more information regarding the technical details, reference is made to Nakamoto (2008). To summarise, the blockchain technology at first glance exhibits some special features or characteristics, which at the same time represent the key advantages compared to other respective information technologies (Fridgen et al., 2018; Kouhizadeh & Sarkis, 2018): 1. decentralisation, 2. transparency and auditability (through tamper-proof process history), 3. data integrity, security and immutability.

The second development stage of the blockchain technology extends the preliminary first field of application and promises even greater use cases through the integration of smart contracts – also known as: digital contracts or e-contracts (Gallay et al., 2017; L'Hermitte et al., 2018; Swan, 2015; Wu, 2018). Smart contracts are transactional protocols or scripts that encompass the terms of contracts and business rules, which run on the top of blockchains embedded in digital codes with software that automatically conduct the negotiated terms of contract agreements to which the respective participants previously agreed (Liao & Wang, 2018). They are stand-alone programmes that check the pre-defined conditions of a contract agreement, and if these are met, a certain number of actions (e.g. transactions) are triggered according to the contractual agreed conditions (Kouhizadeh & Sarkis, 2018). Accordingly, smart contracts are able to read and write from the blockchain, and enable whenever a certain transaction occurs that further transactions are automatically executed (García-Bañuelos et al., 2017). The smart contract computational code is self-executable, fosters and verifies the completion of a contractual arrangement or transaction and represents one of the simplest forms of decentralised automation with the positive effect that human interventions in contracts as well as the presence of trust among the contractual participants becomes superfluous (Kouhizadeh & Sarkis, 2018; Liao & Wang, 2018), which leads to the emergence of decentralised autonomous organisations (DOA) (Manski, 2016). The contractual conditions and related legal principles to be observed are programmed as algorithms in smart contracts that are transparently stored on the distributed and decentralised blockchain network (Kouhizadeh & Sarkis, 2018), where they are shared among other things with their digital record and signature among the authorised contractual participants as well as secured from distortion, revision, tampering and deletion due to the special features of the blockchain technology mentioned above (Liao & Wang, 2018). Accordingly, the usage of smart contracts based on blockchain technology further removes the value of former involved third parties (e.g. intermediary, middleman, broker or agents like government, bank, lawyer, etc.) in diverse business activities, which in addition reduces transaction costs and fosters the efficiency and redesign of complex business processes and logistics networks. Considering the example of a public registry for land titles from García-Bañuelos et al. (2017), where the registry is compiled as a blockchain that records the land tenure, the disposition of a property as a collaborative business process can be configured as a transaction, cryptographically signed by both contractual parties. By using a smart contract this sales transaction together with the related funds, taxes and land titles might be automatically transferred in one and the same action. In practice, such a comparable kind of e-notarisation example is already in place. In December 2015, the firm called Bitnation cooperated with the Estonian government for the implementation of a public notary to e-residents that ensures the notarisation of marriages, birth certificates, land titles, business contracts and safe spaces on basis of the blockchain technology (Manski, 2016).

Besides all potential use cases, logistics bears some of the most pervasive blockchain application possibilities (Kouhizadeh & Sarkis, 2018). Indeed, in the frame of digital document exchange and the tracking of goods, the blockchain technology can foster the complex flow of information, goods and services from their origins to the customers through its inherent features of transparency, security, immutability, decentralisation and public availability, whereby especially the two latter characteristics allow all respective parties to participate in logistics processes (Liao & Wang, 2018). The blockchain technology also offers great potentials for the formation of e-logistics, which faces the attribution to be a complex system of producers, distributors, resellers, carriers and consumers, with digital data flows (ibid.). Taking into account the coordination and integration challenges of the different supply chain parties, the technology behind blockchain in conjunction with smart contracts might enable the development of a virtual ERP system for the supply chain management through the sharing of the same information among the different participants, which triggers, if a demand is occurring, that all relevant parts of the respective supply chain might get immediately orders to generate the needed components (Hofmann & Rüsch, 2017). At the same time, additionally, this would improve the efficiency and flexibility of logistics networks. An important issues which makes the application of blockchain technology including smart contracts even more interesting, is stressed by García-Bañuelos et al. (2017), who advice that especially supply chain and logistics processes traditionally rely on the involvement of trusted third parties, which exhibits as a centralised architecture high entry barriers for SMEs and entrepreneurial firms as well as hinders process innovations, whereby blockchain as a complementary approach facilitates to perform these processes in a peer-to-peer fashion. In addition, it is reasoned that through the adoption of blockchain technology, on the one hand, logistics providers could transparently display their availability to the whole market, which makes them more independent from transport brokers, and on the other hand, different smaller suppliers could consolidate their production outcomes in order to fulfil volume orders, so that they are empowered to sell directly to the retailers instead of a middlemen. However, next to these examples the current research on the adoption of blockchains and smart contracts in supply chains and especially in logistics networks is still limited or just at the beginning (Liao & Wang, 2018), despite the advantages of authentication of traded products, disintermediation, and decrease of transaction costs (Nowiński & Kozma, 2017). To the best of our knowledge, currently there exist no published work that discussed how smart contracting and blockchain technology can facilitate the implementation of collaborative business structures for sustainable trans-national entrepreneurial activities in logistics networks. To address this issue, we use the case of a simplified charter-party contract process with a single voyager in the freight market, in particular break-bulk market, where multiple parties are involved, in order to showcase and assess the potentials of using smart contracting.

Methodology

In the framework of the given study, the theory based and practice related research have been applied built upon comprising qualitative expert interviews, surveys and practical findings that have been originally collected and produced in the frame of several EU projects with a focus on the ongoing project “Connect2SmallPorts”. This project is implemented in the framework of the INTERREG VA South Baltic programme. Among other things the project focus mainly on improving cross-border connectivity for a functional blue and green transport area, with the objective to improve the quality and environmental sustainability of transport services in the Southern Baltic Sea Region. Apart from the systematic literature review, analysis and study of relevant theories and concepts, relevant policy regulations and guidelines, the research findings demonstrated here have been mainly based on primary and qualitative data collected directly by the projects’ partners, associated organisations and project interest groups. The primary empirical data sources were gained in form of evidence-based observations (here: case studies), empirical data from quantitative surveys and qualitative expert interviews with the involved project experts, researchers and relevant stakeholders, observations gathered from respective project activities such as workshops, conferences, round table discussions and open seaport thematic conferences with relevant stakeholders. Furthermore, gained research findings have been validated and verified by the main project target groups during practical workshops and targeted seminars. The main target groups include: policy makers that are responsible for the ports’ and infrastructure development; ports’ and terminals’ operators, incl. cargo handling companies; international associations and corporations involved in the port-related value chains; shipping companies, ship building yards; relevant academic and research institutions as well as regional industries that might benefit from governmental investments and higher data security.

Research results and discussion

In the following, we firstly describe a simplified charter-party contracting process within a single voyager in the break-bulk market, in order to show exemplarily the present situation in the freight market. Generally, the charter-party contracting process embraces the phases: pre-fixture, fixture, post-fixture loading and post-fixture discharging. Afterwards, we will discuss the application possibilities for blockchain-based smart contract implementation to arrive at an optimised process flow, and showcase the arsing potential benefits of the appropriate technology usage.

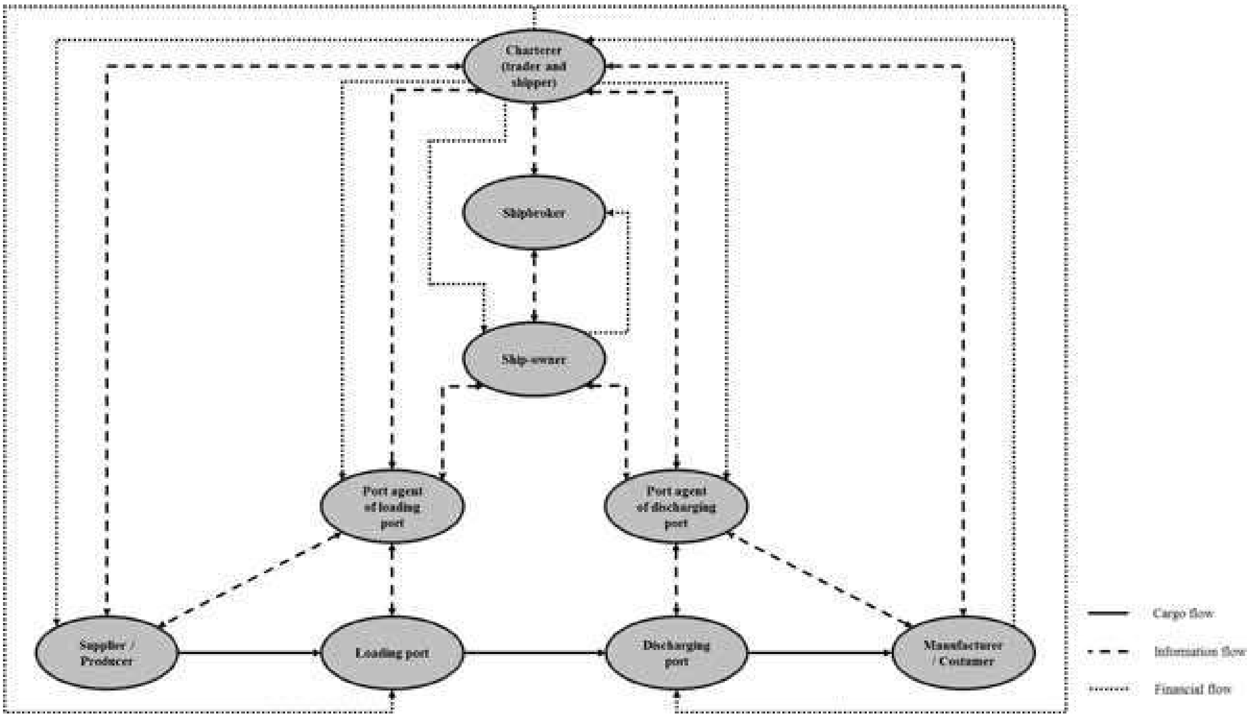
Pre-fixture phase: The process usually starts with a charterer, who is in our simplified case also the trader as well as the shipper or at least closely related to these parties. In the initial situation, the charterer has fixed a sales contract with a supplier, e.g. wood logs as break-bulk. Since the further processing company is far away (e.g. in another country), the charterer is looking for a transport (i.e. ship), and thus would like to achieve a charter-party contract with a ship-owner. The ship-owners have vessels or ships available for cargo that needs to be transported from an origin port to a destination port – also known as loading and discharging ports or exporting and importing ports. Usually, the charterer appoints a shipbroker to find a suitable ship for his cargo. Before the shipbroker can check the current market situation, he ask the charterer for several information, like: name and address as well as contact details of charterer, cargo type and quantity as well as physical dimensions, loading and discharging ports and rates, expected laycan, etc.

Fixture phase: In this process phase, the shipbroker searches for a suitable vessel according to the cargo specifications, period of time and expected rate(s). He contacts several ship-owners and starts the process of negotiation with them on behalf of the charterer. This procedure may be finished in some hours, but often takes few days or even weeks. When the shipbroker has found a suitable ship according to the initial conditions, he sends the offer including initial terms and conditions of the charterer to the ship-owner. The ship-owner needs to check the offer from the charterer, and performs pre-calculations according to the offer and sends the initial time charter or freight rate (here simplified as: general charter rate) to the charterer via the shipbroker – whereby in some cases the shipbroker also has an initial charter rate idea. This negotiation procedure may result in a consensual agreement, a counteroffer, or a disagreement, which may takes some time, since this process is not automated and thus causes that the relevant offers or documents are send back and forth. Independently, what the charterer or ship-owner decides, the shipbroker acts as the intermediary between the charterer and the ship-owner, and receives the decisions and information of both parties and communicates theses decision with the charterer and ship-owner. Once the charterer and the ship-owner agreed to the charter rate, terms and conditions that are transmitted by the shipbroker to each party, the shipbroker prepares the contract with the agreed rates, terms and conditions, for final fixture. Accordingly, the charterer and ship-owner check the charter-party contract in a final step and sign this final contract if all terms and conditions are correct. In an optimal case, the signed charter-party contract contains all relevant information, e.g. details regarding the ship-owner and charterer as well as shipbroker, ship details, brokerage fee (commission), charter rate, cargo and carriage specifications, loading and discharging ports and rates as well as dates, laytime, demurrage and despatch rates, freight payment, payment terms and details including currency, and other obligations and rules as well as clauses. Therefore, also legal aspects and responsibility in case of unexpected events or in case of non-performance are integrated in the charter-party contract. Accordingly, especially for voyage charters typically standard charter-party contracts are used that cover the most relevant clauses that needs to be considered (e.g. NUBALTWOOD, GENCON, etc.). Nevertheless, also in case of time charters some standard forms exist (e.g. ASBATIME, BALTIME, GENTIME, LINERTIME, NYPE, etc.).

Post-fixture loading phase: This phase embraces mainly monitoring tasks. Normally, the ship-owner and the charterer are not personally present at the loading and discharging ports. Accordingly, they appoint port agents at the loading and discharging ports and give them the necessary information and instructions. This represents an additional clause, which is usually also clarified in the charter-party contract in advance. Regarding the lading sub-process at the origin port, the port agent monitors the loading progress, stevedores, bills of lading, notice of readiness statement (NOR) and vessel's statement of facts (SOF), etc. Furthermore, the port agent sends progress information to the ship-owner and charterer, as well as audits and transmits the freight receipt.

Post-fixture discharging phase: In the first place, also this phase contains mainly monitoring tasks. Regarding the discharging sub-process at the destination port, the port agent monitors the discharging progress, notice of readiness statement (NOR) and vessel's statement of facts (SOF), payment status, etc. Additionally, the port agent sends progress information to the ship-owner and charterer. After successful discharging, the ship-owner and charterer perform concluding calculations based on the agreed charter-party contract. If both parties come to a concluding joint outcome, the charterer arranges the payment of the ship-owner and the ship-owner pays the shipbroker. However, if both parties do not reach a joint concluding consensus regarding the invoice, a dispute between both parties may arise and causes additional unnecessary delays. Finally, this might lead to the involvement of lawyers, or the shipbroker as a mediator. However, for such reasons, and in order to avoid legal disputes it is important that the charter-party contract is quite detailed and sound.*

Figure 1 exemplifies the present situation in the freight market (in our case, the break-bulk market).



Source: Authors' own construction and compilation.

Fig. 1. **Present situation in the freight market**

The present situation of the charter-party contracting process exhibits several possibilities for improvements, which can be partly empowered by the implementation of blockchain or smart contract technology, respectively. Therefore, in order to improve the entire charter-party contracting process, we propose a blockchain driven smart contracting system for the efficient direct connection of charterer and ship-owners. As a result, this will enhance the information and cargo flow of the overall logistics network and foster entrepreneurial collaborations.

In the pre-fixture phase, the charterer seeks for a ship and the ship-owner for cargo, which at the end should lead to a charter-party contract between two suitable parties in the fixture phase. Some of the relevant information from the charterers' side in the pre-fixture phase are: cargo type and quantity as well as physical dimensions, loading and discharging ports, expected laycan, etc. On the other hand, the ship-owners' relevant information embraces such as: ship type and size, current position, period of availability, etc. In the current situation, the charterer appoints a shipbroker for the generation of potential offers according to the respective situation on the market – here: break-bulk market. Accordingly, the shipbroker administer the shared information of both involved parties and searches matches. Especially this initiation phase between charterer and shipbroker can be facilitated through a sharing information platform via

* In this context, it needs to be mentioned that the payment could also be arranged during an earlier date, e.g. before discharging, on discharging, or as instalment during contract term, etc.

Internet such as OpenSea.Pro. OpenSea.Pro is a web-based chartering marketplace system, which simplifies the work of shipbrokers, as it facilitates the monitoring of the respective situation of the global freight market in real time, shorten the search of matches through the entered and stored data of charterers and ship-owners, and eases the communication procedure with the respective parties and the shipbroker. Hence, there are already virtual marketplaces in place, where charterers and ship-owner can easily make contact to each other according to their entered initial conditions and characteristics. Therefore, these comparable platforms – like OpenSea.Pro – are able to connect both parties directly without the necessity of intervention through shipbrokers, what at the same time streamlines the process of matching suitable potential contract partners and saves time as well as enable the exchange of relevant information in further stages of the entire cargo voyage process.[†] On the other hand, this pre-fixture phase in conjunction with a virtual marketplace also represents the possible starting point for the implementation of a blockchain and smart contract application. An implemented smart contract application could compare the shared initial data from charterer and the ship-owner and thus, automatically check whether the pre-conditions for a match are fulfilled. Accordingly, some kind of pre-contracts can be automatically generated, as the shared initial data of the participants represent the initial information and pre-conditions that must be given and fulfilled for the development of a charter-party contract.

The fixture phase is mainly dominated by negotiation activities between charterer and ship-owner, whereby the information flow in the current situation is once again organised via the shipbroker. Once, a suitable vessel was found by the shipbroker according to the pre-defined conditions, the shipbroker sends the initial offer to the ship-owner. The ship-owner itself checks the initial offer and performs respective pre-calculations. Afterwards he sends the charter rate to the charterer via the shipbroker. This negotiation procedure may result in a consensual agreement, a counteroffer, or a disagreement. This negotiation process can be extremely time consuming, since currently this process is not automated. Once the charterer and the ship-owner agreed to the charter rate as well as terms and conditions, the contract will be prepared with the agreed rates and clauses, for final fixture. This process phase represents a further connecting factor for the implementation of a smart contract application. For instance, Norta (2015) already developed a smart-contracting setup lifecycle for the negotiation procedure, which might be seen as a viable foundation for the transition and implementation in the context of smart charter-party contracts. In addition, the existence and present usage of standard charter party contracts further foster the potential of extensive automation via smart contracts, since charterer and ship-owner appreciate that standard charter party contracts cover the most relevant clauses that needs to be considered. Additionally, indices – like the Baltic Dry Index – that are usually used in practice function as a possible orientation (e.g. hurdle rate) for price negotiations between the charterer and ship-owner, whereby the respective market data as input data could be automatically integrated in the smart contracting negotiation procedure. As a result, once both parties accept the rates and terms, the charter-party agreement is fixed, and is automatically elaborated via smart contracts and stored on the blockchain. Through this, the charter-party contract becomes decentralised secured, fraud-resistant, immutable, transparent and permanently auditable and accessible for all involved parties during the cargo voyage.

The post-fixture loading phase embraces mainly monitoring tasks that are executed to a certain degree by the appointed port agent in the loading port. These monitoring activities refer to the loading progress, stevedores, bills of lading, notice of readiness statement (NOR) and vessel's statement of facts (SOF), etc. The relevant information gained from the port operations are send to charterer and ship-owner, and function as relevant input data for the final calculations in the post-fixture discharging phase. In the current situation mainly documents, copies and time sheets are transferred between all involved parties. Also in this stage, the blockchain technology can be integrated and optimise the process flow. Through the usage of IoT (i.e. especially smart devices), the relevant information received from the loading activities in the origin

[†] Another interesting solution represents MarDocs, which was developed by the Marcura Group and is a cloud-based collaboration tool for charterers, ship-owners and shipbrokers, which also aims to streamline the charter-party process.

port can be up-loaded and stored on the blockchain. Thus, again, all relevant documents and information are decentralised secured, fraud-resistant, immutable, transparent and permanently auditable and accessible for all involved parties. As smart contracts are able to read from and write on the blockchain, high priority documents like vessel's statement of facts (SOF) or bills of lading can be automatically generated by an implemented smart contract application – if all pre-defined conditions are fulfilled, and thus all necessary information are available on the blockchain through other up-loaded, secured and shared files.

In the post-fixture discharging phase, similar monitoring activities occur and lead to the flow of information between all involved parties. Accordingly, also in this sub-process, comparable integration-efforts for blockchain and smart contracting applications are reasonable as described in the post-fixture loading phase; IoT applications feed the blockchain with necessary input data and smart contracts process these data for further actions or transactions, respectively. In the current situation, additionally to the monitoring tasks, this phase is also characterised by the final concluding calculations by the charterer and ship-owner on the basis of the previously fixed charter-party contract and all collected data that was generated during the entire voyage of the cargo. Finally, this phase should lead to the payment of the ship-owner. Also the process of calculating the different expenses (e.g. demurrage and despatch) can be automated via smart contracts as the relevant rates are recorded in the charter-party contract and thus, in our optimised process, secured on the blockchain. The other important input data, which is needed for the final calculations via smart contracts, are served in our optimised process flow through the used IoT applications. Based on all available and secured data on the blockchain – collected by all involved process parties during the cargo voyage and IoT applications – an implemented smart contract is able to generate – next to the automatically calculable expenses – also the respective invoices. In addition, if all requirements and conditions are fulfilled the smart contract is also able to trigger automatically the respective transactions (i.e. payments) according to the automatically generated invoices. Through the integration of smart contracting in this calculation and payment process, the emergence of objections through the charterer and ship-owner can be limited to a certain degree due to the decentralised nature of the smart contracts or blockchain, respectively. This can be traced back to the fact that the automated calculation of expenses lies on the previously agreed charter-party contract including the different rates and terms as well as on the documents and data that was elaborated through relatively independent third parties like the port agents. This procedure guarantees a fair and trustful method of calculation. Accordingly, a dispute between the charterer and ship-owner might be less likely. This makes the involvement of lawyers or the shipbroker as a mediator superfluous and prevent delays of the entire process.

The advantages of an integration of a blockchain smart contracting system in the ecosystem of a virtual marketplace are numerous. For instance, in combination with IoT devices, the cargo flow becomes trackable and the necessary data generation for feeding the smart contract application is enabled, whereby among other things the possible incorporation of GPS shipping data could even foster this development. Furthermore, the data transfer between incompatible systems in the entire process can be avoided (i.e. higher flexibility) and the data exchange becomes digital and automated, which both streamline the process and information flow as well as saves time, since no sending of documents via courier is necessary. This is also reasoned by the fact that all relevant documents and data are stored on the blockchain, which secures every time availability for all involved parties during the entire cargo voyage, and therefore replaces the paperwork with multiple versions of documents and physical signatures, whereby each authorised participant can digitally sign via a private key, validate documents and receive copies, if necessary. Since in each cargo voyage, many but every time different particular parties are involved, a permissioned blockchain would be an appropriate choice for these purposes. Furthermore, within a permissioned blockchain it is possible to clarify the access and modification rights according to all involved parties as well as proof of personal identification. In addition, some actions or transactions can remain private to certain participants like price negotiations and the results thereof, in a way like a data filter so that certain authorised participants only add, receive or view relevant necessary data and information that are crucial for respective further operations in their area of responsibility. On the other hand, a simultaneous document processing and process tracking is enabled, which foster the transparency of the entire process. Overall, through the blockchain storage, all relevant documents become decentralised secured, fraud-resistant, immutable, transparent and permanently auditable and historically retraceable as well as accessible for all involved and authorised parties during the cargo voyage, which foster the trust among all participants and the efficiency of the entire process due to a higher flexibility. Furthermore, especially through this blockchain recording, the smart contract application possibilities receive great fields of application. In particular, relevant documents like charter party contracts can be elaborated automatically through a smart contract, if all pre-defined conditions that are available through the shared and stored data on the blockchain are fulfilled. This includes also the automation of auditing processes of documents and negotiation procedures and the incorporation of external data that is available on the market, e.g. Baltic Dry Index on the freight market for price negotiations. On the other hand, concluding calculations are automated as well through smart contract application, since calculation basis is given through the underlying blockchain. Accordingly, an implemented smart contract is able to generate also the respective invoices and if all requirements are fulfilled, can trigger automatically the respective payments. This smart contract implementation guarantees a fair and trustful method of expense calculations as well as decentralised monetary transactions. All these aspects mentioned here in the frame of the optimised process flow reduce costs due to shorten process time and lower manual activities.

Nevertheless, of all advantages that become visible in the described optimised process flow for a charter party contract, especially the possible exclusion of the shipbroker as the central intermediary between charterer and ship-owner can have far-reaching positive impacts on the entire logistics networks. In such a setting, where it comes to the implementation of a blockchain driven smart contracting system for the elaboration and conduction of a charter-party agreement in the ecosystem of a virtual marketplace, the shipbroker becomes superfluous. To be more detailed, the integration efforts of smart charter-party contracts replace the shipbrokers and therefore reduce the layers of intermediaries in the logistics networks through the direct connection of ship-owners and charterers. Through the contract automation on a web-based marketplace, the ship-owners could transparently display their service supply and period of availability to the charterers, who in a similar way could show their time-bound service demand to the ship-owners, without the interposition of a shipbroker. Through this, the flow of information is also shorten, which additionally saves time. The exclusion is also reasonable, as the cause of trust through the former presence of the shipbroker, may be compensated by the decentralised nature and other advantages of the blockchain or smart contract, respectively, which automatically lead to the emergence of trust among all participants. Furthermore, there are cost savings with potential spill-over effects that arise through the extraction of the shipbroker. At first glance, the brokerage fee or commission is saved by the ship-owner. Depending on the fact whether a voyage charter or a time charter is achieved, each shipbroker receives a commission on the gross freight or hire price for the ship. Furthermore, the brokerage fee is also dependent from other impact factors like type of cargo, kind of fixed ship, negotiations and agreements with the ship-owner, etc. For instance, within voyage charters the commission may vary between 1 and 5 %. Against this, in the frame of time charters, the brokerage fee amounts typically 2.5 % of the hire price. Since the ship-owner has to pay the shipbroker, regardless whether the charterer previously appointed the shipbroker, this leads to direct cost savings for the ship-owner. Through this, the ship-owner might be able to lower the charter rate for the charterer, which might be regarded as a spill-over effect. Furthermore, this could also lead to higher payable loading and discharging rates at the ports. Accordingly, the absence of a brokerage fee indirectly could have also positive effects to all involved participants on a monetary basis (e.g. seaports through higher wharfage and port dues). Hence, the exclusion of shipbrokers is value adding to the entire logistics networks. Especially for smaller and entrepreneurial actors this foster competiveness, increases efficiency and facilitate participation through the enabling adoption of this new technology due to potentially arising spill-over effects.

Conclusions, proposals, recommendations

Smart contracts are transactional protocols or scripts on the top of the blockchain technology that are created for executing and enforcing legal contracts. Self-executable they check contractual pre-defined conditions and automatically fulfil respective actions or transactions, respectively. Through this form of automation, the layers of middlemen can be reduced or even completely replaced. Accordingly, smart contracts bear the potential to decrease transaction and enforcement costs. Nevertheless, our research revealed that the potential of smart contracts can go far beyond cost reductions by facilitating entrepreneurial collaborations of cross-organisational business-processes that are characteristic for smart logistics networks.

The case study of a charter-party contracting process within a single voyager in the break-bulk market highlighted the potential of blockchain technology and smart contracts to simplify the business processes in the freight market with increased efficiency. All identified aspects in the frame of the optimised process flow reduce costs due to shorten process time and lower manual activities, whereby the potential exclusion of the intermediary is especially value adding for smaller and entrepreneurial actors, since their competiveness and efficiency may be improved and participation facilitated through the enabling adoption of this new technology due to the emergence of spill-over effects. This exemplifies that smart contracts encase the potential to foster entrepreneurial collaborations of cross-organisational business processes and enable trans-national networks of entrepreneurs and SMEs to enter into new business sectors.

In general, further research should have a deeper look on the positive effects that arise from the exclusion of shipbrokers in the context of transaction cost theory. Furthermore, the legal aspects that must be overcome in the frame of the development of smart charter-party contracts needs to be thoroughly analysed, as so far they have not been discussed here. Another interesting future research field would be to develop such a respective smart contract for charter-parties.

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