IMPLICATIONS AND DEVELOPMENT PATHS FOR FUTURE APPLICATIONS OF BLOCKCHAIN TECHNOLOGIES IN LOGISTICS

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ABSTRACT

Blockchain technologies in logistics have been gaining attention from research and practice in the last years contributing to end-to-end transparency and the tracking and tracing of goods and services. Nevertheless, anticipating future changes and dealing with future implementation hurdles poses challenges to companies and researchers. This paper aims to develop theses that describe the future direction of logistics parameters through the use of blockchain technologies. Additionally, these theses are quantitatively evaluated in the two dimensions probability and impact. For this purpose, ten theses are first identified based on three exploratory case studies that have been investigated. Subsequently, these theses are evaluated by 30 logistics and blockchain experts by means of a questionnaire. From the obtained quantitative data, conclusions are drawn for the research objective. The data obtained is merged into a two-dimensional matrix. The resulting four quadrants classify future development streams of blockchain in logistics and indicate variations in the design of networks. From a theoretical point of view, the theses presented identify research needs that can serve as a starting point for

problem-specific research. Furthermore, the evaluation provides an assessment of the relevance of individual development paths and can thus serve as an indication of future prioritization of research. From a practical point of view, the results can be used to anticipate changes in logistics networks and to initiate necessary changes for a paradigm shift towards decentralized data in logistics. The results are limited due to the selection of case studies and the corresponding industries as well as the number of participants of the workshop. Further research is necessary to broaden the insights of this paper.

Keywords
Blockchain, Distributed Ledger Technologies, Logistics, Digitalization, Sustainability

1. INTRODUCTION

Current developments in global logistics are characterized by the automation and digitization of planning and control processes, the holistic end-to-end orientation of value creation systems to differentiated customer requirements, and a comprehensive improvement in sustainability. Logistics networks are becoming increasingly complex and pose new kinds of requirements in terms of their ability to integrate, cooperate and communicate. Achieving end-to-end transparency and the data availability and integration required for this, preferably in real time, from the raw material supplier to the end customer, is one of the greatest challenges for globally operating companies, and one that is gaining additional importance in the wake of the COVID-19 pandemic (Straube et al. 2021; Straube et al. 2019; Straube and Nitsche 2020).

One of the currently much discussed technologies are blockchain technologies, which enable advantages for international logistics networks like transparency and traceability of processes and states as well as trust in the available data via decentralized data storage (Sharma 2018; World Economic Forum 2019). Additional to the historically leading finance sector, promising use cases evolve in transportation and shipping, logistics management, healthcare, manufacturing, public transport, resource sharing and energy (Beck 2017; Underwood 2016). Taking a look at blockchain in logistics specifically, the technology is expected to transform logistics network as, together with artificial intelligence and the Internet of things, one of the current main trends (Pettey 2019). When using blockchain technologies, data, respectively transactions are stored in blocks. These blocks are interlinked by means of cryptographic functions, allowing the entire transaction history to be accessed and traced in the blockchain. In addition, the blockchain is not stored centrally in one instance, but distributed in the network at several nodes. From this basic principle, five functionalities can be derived that are relevant in the context of logistics: decentralization, immutability of data, transparency, security and smart contracts.

Because of the decentralized nature of blockchain technologies, there is no need for central entities or intermediaries to manage data. The trust that was previously placed in these same central entities is now based on rules and consensus mechanisms that provide an agreed-upon process for verifying, validating, and executing transactions. This decentralization creates strong resilience, as there can be no central point of failure and blockchains are difficult to attack due to redundant and distributed data storage. Furthermore, the data is largely immutable, making unintentional manipulation of the data almost impossible and only theoretically conceivable over 51% of the computing power when using proof of work consensus mechanisms or quantum computer attacks. Furthermore, due to the distributed storage, changes are traceable for every user and cryptographic digital signatures additionally guarantee the integrity of the transmitted data. The transaction history of the blockchain can be viewed by all users. This transparency and visibility increase trust and verifiability of data across the network. However, depending on the use case, it may be important not to share sensitive information transparently across the network. Private networks or certain architectures can help address these issues in such cases by only proving that the transaction took place without disclosing the content or participants, while storing sensitive data outside the blockchain. Based on public- private key cryptography and hash functions, blockchain guarantees the authenticity and integrity of exchanged data and transactions, thus providing a high level of security. The final functionality of blockchain is smart contracts, data-driven computer programs that can trigger pre-agreed actions based on transactions and events without human intervention. These smart contracts can be implemented and used as decentralized services and programs on the blockchain (Anderberg et al. 2019).

2. THEORETICAL BACKGROUND

Besides its practical values, also research on blockchain-based logistics networks is gaining a lot of attention in recent years and opens up new ways to deploy and utilize the technology (Lim et al. 2021). The possibilities and application scenarios that can be achieved with blockchain technologies in logistics are diverse and therefore cover a wide range from tracking and tracing products and processes, digitalizing document process, improving working conditions in the supplier network to new ways of decentral planning with positive side effects like avoiding non-essential trips and saving CO2 emissions (Upadhyaya et al. 2021, Queirozet al. 2020)). The functionalities of blockchain technologies enable various applications in the field of logistics, where companies are in constant need of transparency and cross-stakeholder integration. Verhoeven (2022) identified various blockchain applications in logistic and synthesized five application areas within a framework as shown in Figure 1:

- Tracking & tracing

• Financial operations
• Verification & certification
• Planning & network
• Automation & IoT

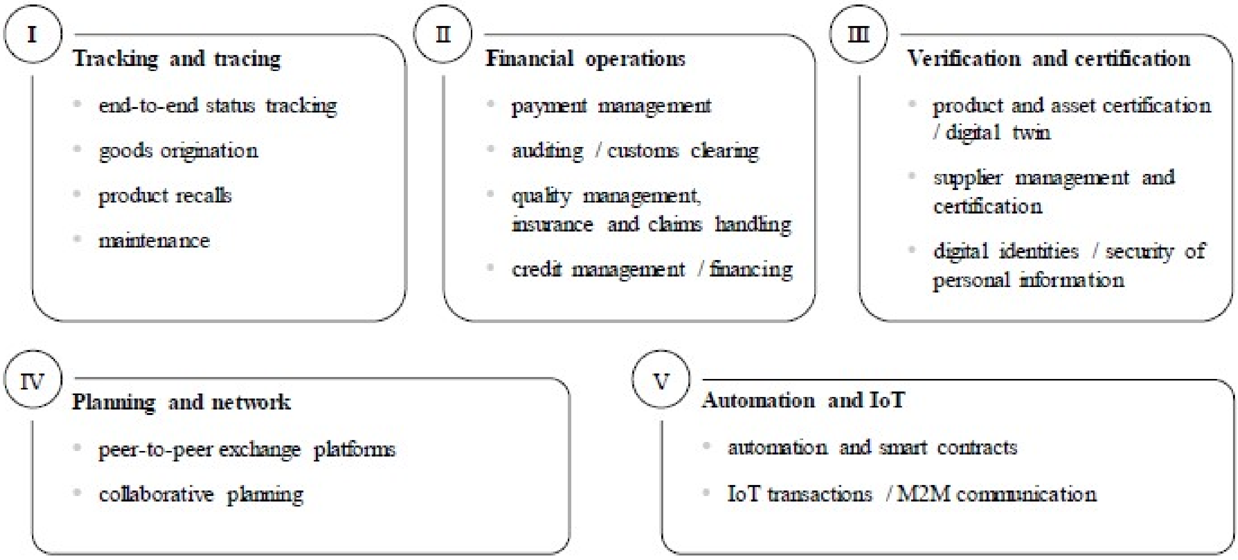


Figure 1: Blockchain application areas in logistics (Verhoeven 2022)

The five application areas show the broad spectrum of possibilities for the use of blockchain technologies in logistics. To begin with, the technology can be used to track and trace products or process steps along the entire network and, if desired, to make the information visible to all partners. In the area of financial operations, decentralized financial transactions between companies without intermediaries as well as application to support audit and customs processes are conceivable. Against the background of global networks, the area of certification and verifications is also relevant as in this context, blockchain technologies enable improved transparency and traceable verification of products and assets. However, network-wide planning tasks can also be supported by the decentralized nature of blockchain technologies, for example by enabling peer-to-peer (P2P) platforms or integrative capacity planning. Additionally, an application area is dedicated to the topic of automation via smart contracts, which enable the cross-company automation of value creation processes in logistics networks (Verhoeven 2021). Despite the large number of potential applications of blockchain technologies in logistics, companies are faced with the challenges of deriving concrete potentials for themselves and anticipating future changes to their networks as a result of the technology (Verhoeven et al. 2018). In the following, we will therefore develop theses on which areas of future logistics will be influenced by blockchain technologies. In the further course of the paper, these theses are then quantitatively evaluated by experts and transferred into an evaluation matrix.

3. RESEARCH QUESTIONS AND RESEARCH MODEL

Despite a lot of research regarding blockchain and logistics and the multitude of possible application areas, it is currently still uncertain which applications will prevail in logistics networks in the long term. This paper therefore aims to identify practical scenarios in logistics that can be solved with blockchain technologies and to evaluate them in terms of their future viability. The scenarios will be formulated as hypotheses and then evaluated in terms of impact and probability. This paper therefore aims to developed the following two research questions (RQ):

> RQ1: How can possible future applications for blockchain technologies in logistics be defined as hypotheses?
>
> RQ2: How can the identified hypotheses be evaluated by means of expected probability and impact on logistics?

The research model to answer these research questions is shown in Figure 2. A multi-method approach is followed. In a first step, the hypotheses are derived based on three case studies. For the evaluation of these hypotheses, surveys with experts from the fields of logistics and blockchain technologies are used, who evaluate each of the identified hypotheses in the dimensions of probability and impact. Subsequently, the evaluations determined in this way can be mapped as average values in a 2x2 matrix and thus provide an outlook on the future viability of blockchain use in the identified scenarios. A detailed description of the methodological approach and the data collected is provided in the next chapter.

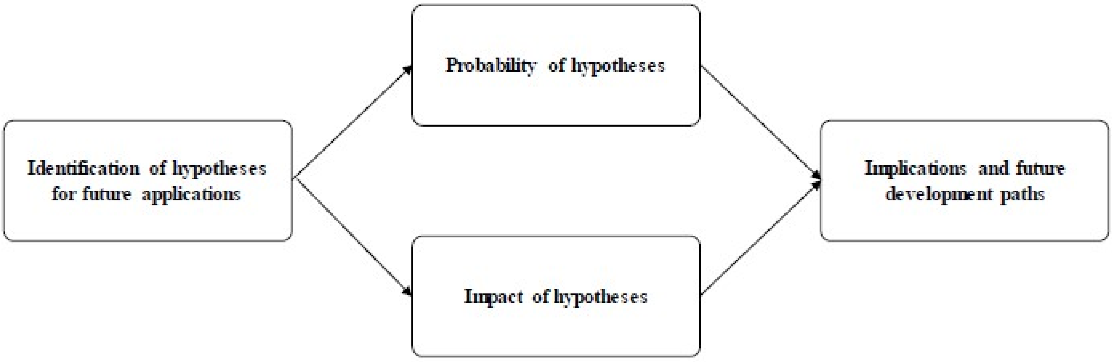


Figure 2: Research model

4. METHODOLOGY AND DATA

In order to identify and evaluate the proposed theses, this paper utilizes explorative case studies as well as a quantitative survey among blockchain and logistics experts as shown in

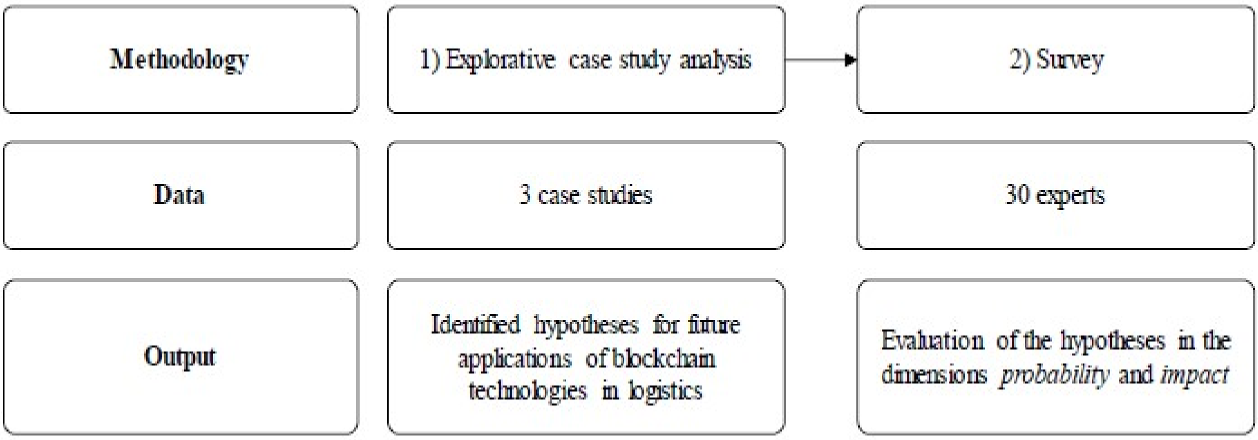


Figure 3: Methodology and data

<u>Case studies</u>

For the case study exploration, we follow the approach by Kittel-Wegner and Meyer (2002), which in the past has already been successfully applied in logistics research. In the context of these case studies, insights from semi-structured expert interviews will be supplemented by additional publicly and non-publicly available materials. As successful blockchain technologies usually cover a wide range of stakeholders of a network and bilateral implementations or with a company are usually not very promising (Ludwig and Stróżyna 2020), attention was paid to a variety of involved stakeholders when selecting interview partners for each case study. An overview of the sample demographics of the selected interviewees is shown in Table 1. Therefore, the majority of the correspondents holds senior level management positions in their companies. As described above a multitude of different stakeholders was involved as manufacturers as well as logistics service providers, technology providers and associations have been involved. This variety is continued in the company size, showing companies with less than 100 employees as well as those with more than 10,000 being involved. In total eight expert interviews have been conducted resulting in 2-3 interviews per case study (Verhoeven 2022).

Interviewee	Management level	Case	Industry	# of employees
1	General Manager	A	Manufacturing	1,000 – 2,500
2	General Manager	A	Technology provider	Up to 100
3	General Manager	B	Manufacturing	100 – 500
4	General Manager	B	Technology Provider	Up to 100
5	Department Manager	B	Technology Provider	Up to 100
6	General Manager	C	Logistics service provider	Above 10,000
7	General Manager	C	Association	100 – 500
8	Team Member	C	Technology Provider	2,500 – 10,000

Table 1: Sample demographics of the case study interviewees (Verhoeven 2022)

The results from the interviews and the corresponding materials will be summarized in reports, which will be discussed with the interviewees afterwards before drawing cross-case conclusion regarding the main theses for the proposed development path of future blockchain applications. As for the selection, of the case studies themselves, care has been taken to select a variety of industries and application areas in an international context. An overview of the conducted explorative case studies in given in Table 2.

Case study	**Scope**	**Industry**	**Application area**
Case study A	International	Coffee	Tracking and tracing
Case study B	International	Automotive	Tracking and tracing, verification and certification
Case study C	International	LSP	Verification and certification, planning and network

Table 2: Case study selection (Verhoeven 2022)

In the following, each case study will be described briefly to give an overview on the subject of investigation. The interested reader is referred to Verhoeven (2022) for a detailed analysis of the three case studies presented here.

Case Study A

The coffee industry is a global network of producers and consumers. While the coffee is mainly grown in areas of South America and Africa, Europe and North America are considered the most important sales regions. In most cases, coffee is grown and harvested in the growing regions, with further processing steps such as roasting often taking place close to the consumer market. Current logistics networks in this industry present several challenges, ranging from lack of transparency to child labor and unfair working conditions, and thus offer potential for the application of blockchain. The case study described here focuses on the Ethiopian coffee production, one of the country's most important export drivers. Here, blockchain was implemented to address the challenges described above. The overall goal of the technology implementation was to be able to provide customers with detailed information about the origin of the coffee as well as to create internal certainty about a socially sound logistics network. For this purpose, 500 farmers and roasters as well as the retailers were connected to a blockchain in order to be able to transparently track the coffee through all process steps. The interface is an app that allows all users to enter data about the products. While the transparency created enables customers to be sure that they are buying sustainable coffee, this furthermore indirectly supports the previously certified and socially sound farms, as they can promote the additional assurance of sustainable products as a competitive differentiating factor. Customers can scan the QR that is individually available on each package and get insights into all process steps that have been passed through since cultivation of the coffee beans. There is also the possibility of financial peer-to-peer transactions between customers and farmers, which are decentralized and are received transparently without intermediaries. The cost-effectiveness of the blockchain solution is evident in the 2.7-fold increase in revenue growth since implementation (Verhoeven 2022).

Case Study B

The second case study to be presented here, in contrast to the previous one, does not deal with a product from the B2C sector, but with materials that are used within B2B logistics networks. The main driver here is therefore not the end customer, but in this case a manufacturer of cars who wants to prove the origin of materials that are considered as conflict materials in the EU and for which corresponding certificates of origin must be provided in accordance with applicable regulations. The findings can be applied to all minerals, but in this particular case the tin industry with origin in Rwanda, further processing in Europe and subsequent use in the German automotive industry was investigated. The tin is mined in large-scale or artisanal and small-scale mines in the central African country of Rwanda, further processed in the country by local smelters and then exported with the help of logistics service providers via Kenya (Port of Mombasa) or Tanzania (Port of Dar es Salaam), since Rwanda, as a land-locked country, has no sea connections. The tin is delivered to suppliers in Eastern and Central Europe via European ports (mainly Port of Hamburg). The modules produced there are then installed in the vehicles at the German plant of the automotive OEM. The core problem of this logistics network is that tin is often mined and processed with disregard for ethical labor. In addition to child and forced labor, applicable regulations are not observed and fair wages are not paid. Due to deep and broad supplier networks in the automotive industry, it is not possible to control all sub-suppliers to ensure compliance with labor rights in developing countries or to source raw materials only from suppliers who comply with them. More transparency could help here, but this is not wanted in the industry due to data privacy concerns in order not to have to share details with (possible) competitors. With the help of blockchain, all actors in the logistics network were connected in a decentralized manner. Thus, mines as well as smelters, transporters and producers can enter product and process data into the blockchain. The implemented solution enables digital certificates that are tamper-proof due to data immutability and the blockchain- inherent viewable transaction history, thus providing adequate assurance regarding the credibility and integrity of the data. This results in processes that are more efficient and enables a reduction in the number of local on-site audits required. To address the data privacy issues, the ability to store both peer-to-peer encrypted data and publicly available data was created. While the former is only viewable by the two respective partners involved, the public data can be accessed by all users of the blockchain at all levels. For example, evidence of certified sustainable tin trades can be stored publicly while details of the transaction (actors involved, volume, prices, etc.) remain private. The investigated case study shows the manifold possibilities of using blockchain in logistics networks with raw material suppliers. The technology enables the balancing act between data privacy and transparency and thus creates the necessary visibility across all levels of supply to ensure compliance with workers' rights in developing countries. Furthermore, digital decentralized certificates enable proof of product origin in order to comply with EU regulations for the import of conflict materials (Verhoeven 2022).

Case Study C

The third case study to be considered does not deal with an entire logistics network, but with a sub-process. In detail, it is about the exchange of load carriers between different logistics service providers, producers as well as retailers in the consumer goods sector. Traditionally, products are packed for transport by the sender on load carriers (e.g. euro-pallet). This load carrier is handed over to a logistics service provider, who then transports the products to the recipient. Since the load carrier initially remains with the recipient, a load carrier exchange is handled by the logistics service provider in order to continuously supply the sender with load carriers and to collect empty load carriers from the recipient after consumption or further processing of the goods. These processes are documented in the pallet bill, which contains all transactions for the pallets. Currently, there is no standardized pallet bill for this purpose, but rather a large number of different variants. Essentially, it is noted how many pallets have been delivered and how many will be returned later. One of the existing problems is that there is often no contractual relationship between the recipient and the service provider, as the service provider is usually commissioned by the shipper. This lack of legal certainty means those agreements are often not adhered to, resulting in additional trips and inefficiencies. In the case study under consideration, the process of exchanging load carriers and the pallet bill was decentralized and digitized using blockchain. Thus, partners of the logistics network can communicate peer-to-peer and exchange information as well as load carriers. In the course of implementing blockchain, a cross-company standardized pallet bill was created at the same time. As a process that is designed without a central intermediary, but was previously rather inefficient as a result, the load carrier exchange can be considered very suitable for the use of blockchain. It was important for the success of the project to gain a large number of partners for sufficient market penetration, as pallets usually rotate across industries. A mobile application was also developed that allows access to the blockchain, thus enabling employees at the loading dock or truck to record transactions or, as well as back office employees, to view pallet inventories. One finding of the case study is that the existing problem could theoretically have been solved without blockchain on a technological level, but the advantages here were primarily used in the context of decentralized management of governance. Thus, governance structures could be developed and hurdles in terms of negotiation and coordination problems could be overcome (Verhoeven 2022).

Survey

Following the case study exploration and the final identification of the proposed theses, we conduct a survey among 30 blockchain and logistics experts to evaluate these theses in two dimensions: probability and impact. The sample demographics of the survey participants are shown in Table 3. Therefore, the participants are mainly positioned in the manufacturing industry followed by logistics service providers and technology providers, but also academia and associations are represented. The size of the companies involved ranges from up to 100 employees to more than 10,000 employees and thus covers a wide range. The majority of the respondents holds high or medium level management positions within their companies.

Industry	**# of employees**	**Management level**
Manufacturing (n=15)	Up to 100 (n=5)	General manager (n=12)
Logistics service provider (n=7)	100 – 500 (n=1)	Department manager (n=9)
Technology provider (n=5)	500 – 1,000 (n=1)	Team Leader (n=5)
Academia (n=2)	1,000 – 2,500 (n=5)	Team Member (n=2)
Associations (n=1)	2,500 – 10,000 (n=6)	Researcher (n=2)
	Above 10,000 (n=12)	

Table 3: Sample demographics of the survey

For each of the theses, the participants are asked to evaluate the probability and impact on a 5-point Likert scale. In this context, probability describes the likelihood that the outcome described in the thesis will become a reality in global logistics networks in the next 10 years. Impact, on the other hand, describes the extent of transformation respectively the effect on the efficiency of logistics networks that the outcome described in the thesis would have, if realized. In a final step, these evaluations will be transferred into a two-dimensional matrix to compare the different development paths and to draw conclusions for future logistics networks.

5. RESULTS AND ANALYSIS

Identification of hypotheses

As explained in the previous chapter, the first methodological step was to conduct the explorative case study in order to synthesize the proposed theses. As a result of this case study analysis we concluded ten theses as shown in Table 4. In the following each of these theses will described in detail before the evaluation results will be discussed.

Theses	
H1: Blockchain technologies will support the digitalization of logistics documents.	H2: Blockchain technologies will be used to track and improve sustainability parameters.
H3: Blockchain technologies will enable clear data ownership to organization and make it easier to share data in a decentralized way.	H4: Blockchain technologies will enable P2P exchange of products and services through decentralized platforms.
H5: Blockchain integration paired with P2P communication enables the utmost openness while preserving data control and privacy.	H6: Blockchain technologies will decrease logistics costs for information gathering, coordination and decision making.
H7: Blockchain technologies will enable the automation of processes between companies through smart contracts.	H8: Blockchain technologies will support the development of standards in logistics.
H9: Blockchain technologies will lead to decentral governance and redistribution of market power.	H10: Blockchain technologies will integrate demand and capacity planning over company borders.

Table 4: Developed theses

H1: Blockchain technologies will support the digitalization of logistics documents

Today's logistics processes are characterized by a large number of required documents. These often have to be carried along the entire logistics network in analog form and signed by different actors due to the lack of a central database solution for these documents. Blockchain technologies can create a decentralized solution for standardized document management in logistics networks according to their inherent characteristics.

H2: Blockchain technologies will be used to track and improve sustainability parameters

As blockchain technologies offer the potential for transparent and verifiable information tracking throughout the entire logistics network, the technologies are applicable to sustainability problems in current networks that often stem from intransparency. The concrete application scenarios are diverse and range from the improvement of working conditions at suppliers, to the fight against corruption in developing countries, to new possibilities for decentralized planning and thus the possibility of more efficient routes, or the avoidance of empty runs to reduce CO2 emissions. Furthermore, a verifiable record of emissions within the entire network can be tracked and reported accordingly

H3: Blockchain technologies will enable clear data ownership to organization and make it easier to share data in a decentralized way

A major obstacle to cross-company data sharing is the lack of control over what happens to data, who gets access to it, and what benefits it brings to whom. There is also a lack of incentivization of companies to contribute to active data sharing. In the future, blockchain technologies can enable clear data ownership, allowing companies to transparently track who has access to their own data, what benefits others may derive from it, and thus create a basis for monetizing their own data.

H4: Blockchain technologies will enable P2P exchange of products and services through decentralized platforms

A key trend in recent years has been the emergence of platforms, in which a central provider without assets often mediates services and products between suppliers and customers. To operate these platforms, a margin accordingly goes down for the central player. Blockchain technologies can help make this process more efficient by allowing the platform to be managed in a decentralized manner by the actors themselves and transactions to be processed P2P. This reduces communication barriers and logistics costs alike.

H5: Blockchain integration paired with P2P communication enables the utmost openness while preserving data control and privacy

As described above, blockchain technologies can enable clear data ownership. This further results in utmost openness in terms of data exchange with simultaneous data control and privacy. Multi-layer architectures enable selection between P2P data, public data and private corporate data on the same blockchain, giving companies full control over their data transparency.

H6: Blockchain technologies will decrease logistics costs for information gathering, coordination and decision making

In current logistics networks, high costs are incurred for internal and external information gathering, coordination and decision making. Through better P2P connectivity of actors via blockchain technologies, these operational and tactical costs can be reduced by lowering communication and data barriers. Better integration improves cross-enterprise coordination and accelerates management decisions.

H7: Blockchain technologies will enable the automation of processes between companies through smart contracts

Smart contracts as data-driven decision models can automate processes across companies. When defined events occur, transactions can be triggered accordingly. Therefore, through the decentralization of blockchain technologies, transparent and traceable process logics can be created between companies.

H8: Blockchain technologies will support the development of standards in logistics

A multitude of non-standardized documents and systems prevents the best possible efficiency in current logistics networks. A consistent implementation of blockchain technologies enables the simultaneous introduction of cross-industry standards by creating an agreement on the required data to be stored in the blockchain by means of a decentralized governance. Decentralization can thus create the backbone for standardized logistics networks of the future, *H9: Blockchain technologies will lead to decentral governance and redistribution of market power*

By decentralizing the data structure, creating clear data ownership and decentralizing governance, it is feasible that smaller players can be more effectively integrated into existing networks and that a redistribution of market power is made possible. Instead of a few central players, entire networks could benefit from better integration and innovation. Decisions can thus be made in a decentralized, transparent, and smart way by everyone to maximize overall benefits.

H10: Blockchain technologies will integrate demand and capacity planning over company borders

The decentralized governance described above and the transparent exchange of information across company boundaries can ultimately enable integrated demand and capacity planning. In this context, the joint use of assets and infrastructure or the exchange of forecasting models for the optimization of planning processes and capacity utilization, also between competitors, are conceivable for mutual benefit.

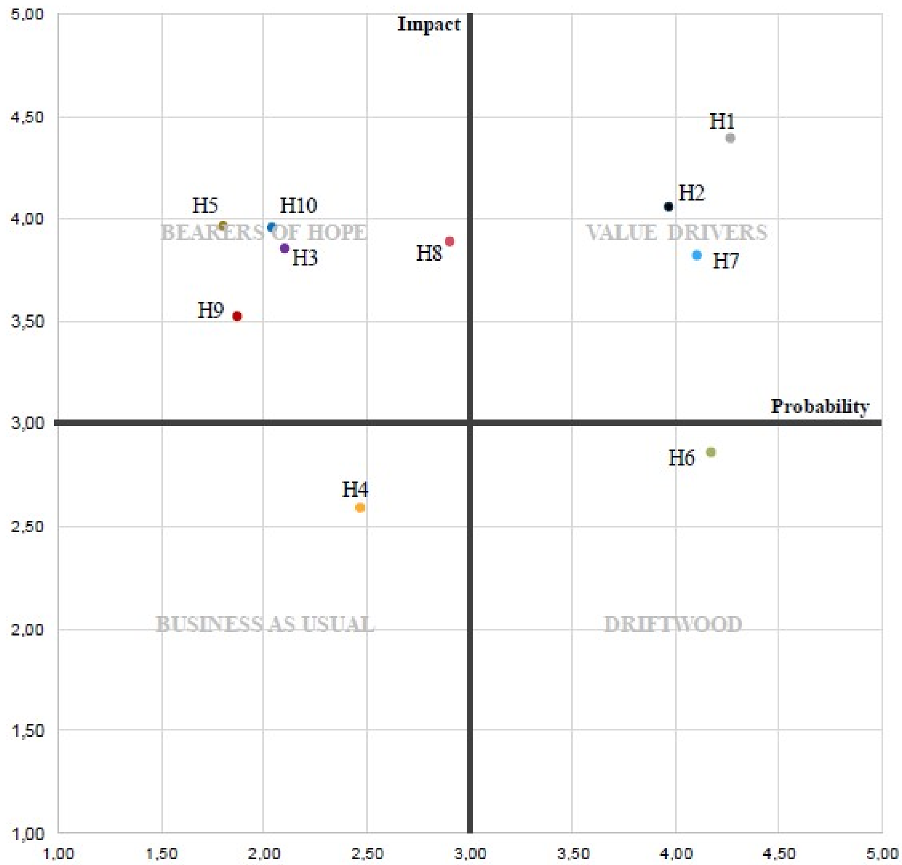
<u>Evaluation of hypotheses</u>

As described above the ten hypotheses were then evaluated by 30 blockchain and logistics experts in the two dimensions probability and impact. Each of the dimensions was evaluated on a Likert scale from 1 to 5 by the experts. The average of all respondents was finally plotted in the matrix for each hypothesis. By dividing each of the dimensions in two halves., this results in a matrix with four quadrants, which can be assigned to a set of characteristics depending on the degree of probability, respectively impact. For a better understanding and for the purpose of illustration, these quadrants have been named accordingly as follows:

- High probability / high impact: value drivers
- Low probability / high impact: bearers of hope
- Low probability / low impact: business as usual
- High probability / low impact: driftwood

As a result of this evaluation, three theses (H1, H2, H7) were evaluated as value drivers, five as bearers of hope (H3, H5, H8, H9, H10) and one each in the quadrants for business as usual

(H4) and driftwood (H6). The results are shown in Figure 4 and will be explained in the following. The results indicate a strong support of the theses H1, H2 and H7 as those have been evaluated with a high degree of probability and impact. The digitalization of documents through blockchain technologies is expected to have the highest impact on future logistics networks, but also the tracking and improvement of environmental and social sustainability parameters as well as the automation of processes across company borders through smart contracts shows a relatively high level of impact while also being high in probability. Evaluated with a high degree of impact, but associated with a relatively low degree of probability are theses H3, H5, H8, H9 and H10. Therefore, it would have a high impact to enable easier data sharing and P2P communication, to apply blockchain technologies to support the development of standards as well as to redistribute market power through a decentral governance and to integrate demand and capacity planning function through decentralization, but the probability to materialize those benefits is evaluated comparatively low by the industry experts. With thesis H6, the logistics costs perspective was evaluated with a high degree of probability, but a relatively low to medium degree of impact showing that experts do expect blockchain technologies to reduce costs for information gathering, coordination and decision making, but that those cost reductions will not be as high as some might expect. Ultimately, the results furthermore show a relatively low support for the thesis H4 and can be interpreted as an indicator that decentralized P2P platforms through blockchain technologies will not be seen industry-wide in the near future.



H1: BCT will support the digitalization of logistics documents.

H2: BCT will be used to track and improve sustainability parameters.

H3: BCT will enable clear data ownership to organization and make it easier to share data in a decentralized way.

H4: BCT will enable P2P exchange of products and services through decentralized platforms.

H5: BCT integration paired with P2P communication enables the utmost openness while preserving data control and privacy.

H6: BCT will decrease logistics costs for information gathering, coordination and decision making.

H7: BCT will enable the automation of processes between companies through smart contracts.

H8: BCT will support the development of standards in logistics.

H9: BCT will lead to decentral governance and redistribution of market power. H10: BCT will integrate demand and capacity planning over company borders.

Figure 4: Evaluation matrix:

6. DISCUSSION

From a scientific perspective, the identified theses initially show which future developments in logistics networks can be derived from current case studies. The ten theses thereby show both technical and organizational changes, each of which brings different potentials for the optimization of network structures. The two-dimensional evaluation of the theses can serve as an indicator for future research to investigate the potentials of individual theses and the associated future perspectives in a dedicated manner. Prominent among these are the topics of applying blockchain technologies to digitize documents, to sustainably design logistics networks, and to implement cross-enterprise smart contracts to automate business processes. For practitioners, the findings of this paper provide an indication for future paradigm shifts in logistics. The results can be understood as a preliminary quantitative assessment and prioritization of future changes. Accordingly, managers can anticipate changes at an early stage and locate companies on the blockchain map according to their digitization strategy. However, it should not be ignored that all technology adoption decisions must be examined with regard to their mindfulness in the specific context (Verhoeven 2018).

7. CONCLUSION AND FUTURE STUDIES

This paper aimed to develop and evaluate theses that describe the future direction of logistics parameters through the use of blockchain technologies. For this purpose, we conducted three case studies on current implementations of blockchain technologies in different scenarios and industry. In a subsequent step we derived ten theses, which feature technological and organizational predicted changes in logistics networks through the implementation of blockchain technologies. These theses range from digitizing logistics documents, designing sustainable logistics networks to enabling P2P platforms, better data sharing and the reduction of logistics costs for information gathering, coordination and decision making. In order to evaluate the proposed theses, we conducted a survey among 30 blockchain and logistics experts. This survey included the evaluation of the probability and impact of each thesis. Accordingly, this resulted in a matrix with four quadrants, which displays the classification of the theses in the four distinguishable quadrants value drivers, bearers of hope, business as usual and driftwood. The results indicate that the blockchain-induced digitalization of documents, the tracking and tracing of sustainable parameters as well as the cross-company automation of business process through smart contracts are the theses with both the highest probability and highest impact on logistics performance. There is high potential in utilizing the technology´s inherent feature of decentralization to build a cross-company distributed data base to digitize documents such as the lading bill or any other documents that need to be shipped with products or assets in order to track and verify processes. This distributed data structure can furthermore more be used to verify the origin of products and related working conditions (social sustainability) or to transparently track CO2 emissions of all involved actors of the logistics network (environmental sustainability). Smart contract as event-triggered decision models can be implemented as a trusted distributed entity to automate processes between companies and to create a consensus on rules to be carried out based on a transparent data exchange. In conclusion, blockchain technologies will undoubtedly have far-reaching consequences for the future design of logistics network. It can be observed, that the potentials of blockchain technologies are slowly materializing within the industry and promising use cases are being implemented into live features of logistics networks. However, research should continue to support the development of blockchain systems in logistics with further evaluations of future impacts, both qualitatively and quantitatively, to assist companies in assessing their own networks regarding applicability and feasibility of blockchain technologies for their specific problems.

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