Journal of Applied Leadership and Management 6, 1 – 17

Benefits and Challenges of Factors influencing the integration of Blockchain Technology

Florian Gottschlich, (florian_gottschlich@yahoo.de)

University of Applied Sciences Kempten, Germany

Summary

Research question: What are the benefits and challenges of critical success factors for the German logistics industry when integrating blockchain technology?

Methods: A survey with six determined factors and their benefits as well as challenges was conducted to analyze the expectations of logistics professionals in Germany.

Results: Cost reduction is achieved by integrating the blockchain through low marginal cost, efficient management of inventory stocks and reduced paperwork. Speed is fostered by reduced interactions and real-time exchange of information. The need of digitalization for the blockchain integration is mostly influenced by the availability of financial resources and integration of hardware components. Transparency, Complexity and Data security were not sufficiently explained.

Structure of the article: Introduction; Literature Review; Research Question; Empirical Design; Empirical Results; Conclusions; Bibliography

Introduction

Supply chains are a highly promising area for the application of blockchain technology as several industrial use cases have shown (Apte & Petrovsky, 2016; Kim & Laskowski, 2016). When it is deployed with Internet of Things applications like sensors, barcodes, GPS and RFID the tracking of products, packages and shipping containers can be done gapless (Franke, Engelbrecht, & Heinert, 2018). Thus, the blockchains have the potential to harmonize information exchange and raise operational efficiencies across a diverse industry. Also, it supports supply chain quality, by facilitating provenance for branded goods, and reducing costs of regulatory approvals (Staples et al., 2017).

Actually, most of the scientific research concern technical, computational, and engineering facets of the blockchain (Beck, Avital, Rossi, & Thatcher, 2017). Fields of scientific interest are examinations of different use cases that potentially can be addressed by blockchain technology (Crosby, Pattanayak, Verma, & Kalyanaraman, 2016; Hopf & Picot, 2018, pp. 113; Seebacher & Schüritz, 2017, pp. 13).

The approach of this article is to examine critical success factors of the blockchain integration from the perspective of possible blockchain adopters. Hence, managers in the German logistics industry are surveyed to assess main factors which influence the integration of blockchain technology. The aim is that a link between critical success factors of digital supply chain and features of blockchain technology is demonstrated. The results provide potential benefits and challenges that businesses are likely to face when integrating the blockchain. It helps to comprehend aspects that should be considered, and addressed in advance, within initiatives and projects of the blockchain integration. Especially blockchain application providers get a better understanding about expectations of their customers.

The literature review focuses on the digital supply chain as one of the underlying concepts of the blockchain. Also the characteristics of blockchain technology which are especially useful for supply chain are emphasized. The research question, elaborated from the concept of digital supply chain and the characteristics of blockchain technology, asks for the critical success factors which are merged into features influencing the blockchain integration. Furthermore information about the methods are given. Subsequently, the determined critical success factors of digital supply chain as well as the benefits and challenges of the blockchain integration are evaluated and the results of the data analysis are presented. In the following conclusion the research theoretical contributions and managerial implications are demonstrated as well as limitations and opportunities for future research are described.

Literature Review

Tremendous technology shifts and innovations have been developed and are available but their integration and efficient application in the supply chain remains problematic (Farahani, Meier, & Wilke, 2017, p. 159). Digital Supply Chain (DSC) is the opportunity to overcome the obstacles that the chain turns into an integrated system that runs flawlessly (Bailey, Moss, & Whittaker, 2015; Gottlieb & Willmott, 2014; Penthin & Dillman, 2015; Seidel & Kutzler, 2014). DSC can be understood as a smart technological system that is based on the capability of massive data allocation and intelligent cooperation and communication for digital hardware, software, and networks to enable optimal interactions between parties by making services more valuable, accessible and affordable with consistent, agile and effective outcomes (Büyüközkan & Göcer, 2018). According to Mattila and Seppälä (2016) the blockchain provides all these requirements.

A DSC leverages new approaches for supply chain with a wide variety of innovative technologies for example drones, cloud computing, Big Data, and Internet of Things (IoT) (Büyüközkan & Göcer, 2018). Recent scientific papers highlight the importance of DSC and several industrial researchers discuss its components and technologies (Bailey et al., 2015; Büyüközkan & Göcer, 2018; Penthin & Dillman, 2015; Raab et al., 2011; Schmidt et al., 2015). For global organizations, the DSC is the key for organizations' long-term growth and success because it contains some distinct features (Bailey et al., 2015). These aspects are summarized in table 1 as critical success factors which contain either benefits to achieve or challenges to overcome.

A DSC leverages new approaches for supply chain with a wide variety of innovative technologies for example drones, cloud computing, Big Data, and Internet of Things (IoT) (Dijkman, Sprenkels, Peeters, & Janssen, 2005; Kim & Laskowski, 2016; Tu, Lim, & Yang, 2018). The idea of the IoT is equipping everyday objects with perception, recognition, networking and processing capabilities that allow them to interact with other objects and services over the Internet to achieve a useful goal (Whitmore, Agarwal, & Da Xu, 2015). What is missing so far is an architecture model which is suitable for supporting effective connectivity, control, communication, and useful applications for the heterogeneous devices and applications for IoT (Stankovic, 2014). An architecture model with standards to enable interoperability and commercial use of each device can be provided by the blockchain (Mattila et al., 2016).

Table 1 *Critical Success Factors of DSC*

Critical success factor	**Benefits and Challenges**
Cost	• Improved integration of internal processes (Ferretti & Schiavone, 2016; Mann, 2015) • Operational efficiency (Li & Li, 2017) • Better control and management of inventory (Reaidy, Gunasekaran, & Spalanzani, 2015) • Reduction of paperwork (Groenfeldt, 2017)
Transparency	• Real-time visibility (Kumar, Amorim, Bhattacharya, & Garza-Reyes, 2016) • Improvement in products tracking and traceability (Uddin & Sharif, 2016) • Information sharing (Schmidt et al., 2015; Schrauf & Berttram, 2016) • Predictive analytics (Hanifan et al., 2014)

Speed	• Real-time visibility of demand and capacity fluctuations (Schrauf & Berttram, 2016) • Development of reliability, responsiveness and agility through fast exchange of real-time information (Dweekat, Hwang, & Park, 2017) • Accelerate Responsiveness (Hanifan et al., 2014) • Automated executions (Raab et al., 2011) • Reduce human interaction and communication (Raab et al., 2011)
Complexity	• Compliance of diverse laws, regulations and institutions (Hackius & Petersen, 2017) • Lack of clear comprehension about the benefits (Ryan & Watson, 2017) • Risks associated with the implementation of a new business model (Pfisterer, Radonjic-Simic, & Reichwald, 2016) • Lack of required skills (Xu, 2014, p.123)
Data security	• Device and network security risks and vulnerabilities (Riggins & Wamba, 2015) • Loss of privacy, trust and confidentiality (Bhargava et al., 2013) • Lack of trust in new technology (Penthin & Dillman, 2015)
Digitalization	• Interfaces of different technologies and network systems (Hussain, 2017) • Integration with technologies and operations outside operational boundaries (Hussain, 2017) • Availability of financial resources (Lee & Lee, 2015)

The blockchain promotes, in conjunction with smart contracts, the development of IoT, which is based on the merging of virtual and physical systems into so-called cyber-physical systems in industrial production (Burgwinkel, 2016, p. 3). The term blockchain refers to a technology which offers distributed ledgers. Stored data is secured by cryptography, and governed by a consensus mechanism (Beck et al., 2017). The technical concept groups individual data records into blocks which are then stored in a distributed manner on the systems of the network subscribers (Gimpel & Röglinger, 2017). The blocks are sequentially linked with each other so that the chronological order as well as the data integrity of the entire dataset is ensured (Burgwinkel, 2016, p. 5). In the blockchain, new data is combined into a new block and this is appended to the existing chain. Copies of the blockchain are saved on multiple devices, it assures that even if a network node was attacked by a hacker; a sufficient amount of copies persist, so that a block would not be lost (Apte & Petrovsky, 2016). As a result a manipulation of a record is detectable (Skwarek, 2017).

Since the blockchain is only at the beginning of its development, so far, no uniform definitions have prevailed (Mattila et al., 2016; Swan, 2015).

Blockchain systems are distributed systems which are characterized by several properties. Initially, they have several independent network nodes that communicate with each other and synchronize. The failure of individual computers does not affect other computers. In addition, each network node stores a common status of the system so that failure of individual computers does not imply loss of system status (Apte & Petrovsky, 2016).

In blockchain systems, the data is stored redundantly in each node (Morabito, 2017, pp. 5). These, as well as the consensus mechanism, by means of which the network nodes can coordinate the system status can be regarded as the fundamental innovation behind blockchain systems (Bogart & Rice, 2015).

Furthermore, the blockchain offers for the first time a suitable medium for the implementation of smart contracts (Christidis & Devetsikiotis, 2016; Cong & He, 2017; Hegadekatti, 2016; Staples et al., 2017). These are computer programs that can make decisions when certain conditions are met (Kõlvart, Poola, & Rull, 2016, p.134). For this purpose, external information can be used as input through the smart contract, which then causes a specific action via the established rules of the contract (Tuesta, Alonso, & Camara, 2015). According to Swanson (2014), smart contracts are tools that automate human interactions by enabling, enforcing, and inhibiting contracts through algorithms. Thus, the application possibilities are very broad (Clack, Bakshi, & Braine, 2016).

Furthermore various technical-conceptual characteristics can be distinguished in a blockchain system. First, the blockchain can be distinguished in private or public systems (Peters & Panayi, 2015).

In this case, it is crucial by whom the systems can be used, that is, who has access to the data or who may propose new data inputs. If this use is granted to anyone, it is a public system. However, if restricted to an organization or consortium, the blockchain system should be considered private (Welzel et al., 2017).

Another possible differentiation of systems is whether a permission is required to participate in the blockchain management process (Walport, 2016). Are the network nodes that perform a validation pre-selected by a consortium or a central authority, it is a permission-based blockchain system (Peters & Panayi, 2015). In this case, economic barriers, such as an energy-consuming and therefore cost-intensive PoW mechanisms as an incentive for correct behavior in the validation process are obsolete, why more efficient mechanisms for consensus finding can be implemented (Mattila et al., 2016; Swanson, 2014). According to Schlatt, Schweizer, Urbach and Fridgen (2016) permissionless systems are generally public and permission-based systems are usually private. For them, private systems can only be permission-based.

In addition to the PoW used in the Bitcoin system, there are a variety of methods (Bentov, Gabizon, & Mizrahi, 2016). For example, one option is to use a proof-of-stake (Bailis, Narayanan, Miller, & Han, 2017). The basic idea is to ensure that the blockchain is primarily updated by those network nodes that hold a large share of the currency and generally values in the blockchain, thereby providing an incentive to maintain the system correctly should exist (Morabito, 2017, p. 64).

Research Questions

In the following it is shown which features of blockchain technology are beneficial for meeting DSC objectives and on the other hand challenge them. Thereby, the features are assigned to the critical success factors of DSC. As a result six hypotheses are formulated, every hypothesis assumes an influence on one of the critical success factors of DSC through the benefits or challenges of the blockchain integration.

The Blockchain enables to digitally track any kind of good and its information (Kim & Laskowski, 2016).

Walmart conducted a test which was developed with IBM to monitor pork production in China. Thereby, all details for example the food on the farm, the storage temperature in the factory, and the shipping route of the meat can be viewed on the blockchain (Kamath, 2018). These help to check the quality of the products and reduces the need for paperwork's without adding costs. In case of food gone bad, retailers like Walmart are able to easily pinpoint the affected products and remove them instead of recalling the entire product line. Inventories are thus managed more efficiently (Hackius & Petersen, 2017). Another advantage is the use of unit level instead of batch level entity identification. The Blockchain is even able to combine both. This combination is likely to bring transformation in supply chains because it is still efficient to set up blocks for small transactions. Thus, firms can exploit zero or very low marginal costs (Apte & Petrovsky, 2016). Therefore, in the cost context it is expected that:

H1. The low marginal costs for transactions, a reduction in paperwork, and the efficient management of inventory stocks through the blockchain integration reduce costs.

The use of cryptographic principles has various positive properties where the hash function offers various opportunities for transparency(Akram, 2017; Brühl, 2017; Crosby et al., 2016; Francisco & Swanson, 2018). Each block contains a reference to the previous block as well as a timestamp, so it is not feasible for the transactional ledger to be subsequently falsified, or changed (Apte & Petrovsky, 2016). Users can easily verify and trace all the data records by obtaining any node in the distributed network. This is a feature which hinders to manipulate the origin of goods and is a huge advance in comparison with hard copy documents that can be simply replaced by new versions containing different facts (Walport, 2016). Additionally, blockchain systems have a high degree of transparency due to the transaction history that can be viewed for each network node. This simplifies data assessment for all parties involved (Walport, 2016). The detection of origin, genuineness, quality or compliance with environmental standards is important in many industries. It applies for the food industry (Apte & Petrovsky, 2016), for example, in the detection of organic crops, for the extractive industry (Lomas, 2015) for the examination of mining rights or for the textile industry (Francisco & Swanson, 2018), in the review of working conditions in the producing countries. In all these cases it is conceivable to document supply, production, transport and further processing of products completely and forgery-proof in a distributed ledger. The falsification of indications of origin, the non-compliance with quality standards or the improper disposal of refuse would be considerably more difficult (Akram, 2017). Thus, it is assumed that:

H2. The prevention from counterfeit goods, the end-to-end provenance, and the improved analytics through the blockchain integration increase transparency.

The speed of certain processes and operations can be increased with the blockchain. The processing of a transaction is completed with the inclusion in a block and takes only about ten minutes in the Bitcoin system (Böhme, Christin, Edelman, & Moore, 2015). Information about demand and capacity fluctuations can be exchanged in real-time to any node in the distributed network (Reaidy et al., 2015). Besides the technical increase of speed, the whole process of a transaction can be digitized and therefore reduces interactions and communications (Kshetri, 2018). In international supply chains, procedures such as the letters of credit, bills of delivery, and custom clearance are very complex and have intricate information flows. It is important to obtain numerous approvals from several authorities. They need to be communicated efficiently and in the same format (Casey & Wong, 2017). This is exactly the problem solved by the blockchain. Especially the usage of smart contracts, allows automatization where extensive documents need approval (Loop, 2016). The derived hypothesis reads as follows:

H3. The reduced interaction and communication, the automatization, and the real-time exchange of information through the blockchain integration increase speed.

Global supply chains are complex constructs. They require various parties to comply with diverse laws, regulations and different institutions (Cohen, Roussel, & Ehle, 2006, p. 5). In such an environment it is not clear how smart contracts are classified when it comes to court (Kolain, 2017, p. 157). And it gets more complex if they include besides laws and regulations also tax and customs, commercial codes, laws pertaining to ownership, and possession of multiple jurisdictions (Kiviat, 2015). Since international businesses operate in an environment of these established old laws, customs, and institutions that are managed by human beings, adopting blockchain-based solutions can be an extremely complex task (Casey & Wong, 2017). Furthermore, blockchain technology is associated with tremendous complexity and an array of highly-specialized terms which need specialized workforce for programming and usage. Additionally, executives need to have a basic understanding for the technology to support the development of applications in their business (Ryan & Watson, 2017). For the complexity it is anticipated that:

H4. The necessary compliance of diverse standards, the lack of required skills of the workforce, and the missing identified applications for the own business increase the complexity of the blockchain integration.

Data security raises frequently a debate for the blockchain deployment in supply chain (Yli-Huumo, Ko, Choi, Park, & Smolander, 2016). A risk arises from public-key cryptography. If a private key is stolen or lost, the corresponding content will inevitably become unusable (Condos et al., 2015). If, in addition, transaction details are incorrectly entered and sent, the transaction is no longer reversible by the sender (Schlatt et al., 2016). IBM reported that most of the companies working with blockchain solutions from IBM were against an open system such as bitcoin which is an indication for a lack of trust. But, centralized blockchains with a restrictive access must be acknowledged by authorities (Kshetri, 2018). An example is the supply chain blockchain developed by IBM and Maersk. For the network only a limited number of participants exist and all members are known (Hackius & Petersen, 2017). With the so-called 51% attack such a system is vulnerable to infiltrate (Staples et al., 2017) because the amount of devices to hack is much smaller than in a decentralized system. In this attack a hacker alters a block at 51% of the devices (Burgwinkel, 2016, p. 8). Thus, a higher degree of centralization in blockchain technology concentrates power in a handful of entities and is more vulnerable for attacks (Groenfeldt, 2017). The actual strength of the technology, the consensus mechanism in a distributed data system, is thereby lost. For that reason, the hypothesis is:

H5. The fear of privacy and confidentiality loss, the lack of trust, and the fear of data manipulation increase data security concerns of the blockchain integration.

When different blockchain systems are used for specific applications, ensuring the interoperability of these systems is a big challenge. This applies for software and hardware devices in the same manner. A standardization and a given global governance framework can help (Van de Velde et al., 2016). Considering the requirement of high level equipping, not all have access to blockchain-based solutions (Condos et al., 2015). Especially supply chain partners located in developing and least developed countries cannot afford the necessary computerization. They need to be connected to increase the full potential of the blockchain in supply chain (Hackius & Petersen, 2017). But also, multinational companies issue a caveat when implementing blockchain solutions (Kümmerlen, 2018). It exists high barriers to entry, the willingness for investments and the need for competence about the technology does not exist in many companies. The company's own IT department might be motivated by the topic, but it is already well utilized for the maintenance and further development of its own IT structure (Klapdor, 2018). The blockchain must therefore be anchored in separate projects and they will take a long time to pay off (Greenspan, 2015). Maersk, for instance, calculated that costs decrease extremely by the use of blockchain technology, but savings are not expected because investment for research and development exceed them for the next years until the technology is more widely used (Groenfeldt, 2017). Thereto, the developed hypothesis is:

H6. The availability of financial resources, the compatibility of network software, and the integration of hardware components increase the need of digitalization for the blockchain integration.

Empirical Design

The primary data for this study was collected through the use of a web-based survey. The design of the survey was based on information extracted from the available literature to form meaningful, and relevant, questions to prove the formulated hypotheses. The survey consisted of six main questions divided into sub-statements so that a total of 26 items were needed to answer. The participants were asked to share their expectation by rating their responses on a five-point level of agreement Likert scale. The main source of primary data were practitioners who are experienced in the German logistics industry and in the development of blockchain technology for supply chain. The data was collected during May and June 2018. In total, 1,878 people viewed the post on a social network for professionals, 143 started completing it, and 140 fully completed surveys were received resulting in a response rate of 7.4%. 38 participants can be assigned to the engineering industry. It is composed of automotive, defense, manufacturing, aerospace, and maintenance. Behind it follows the area of IT with 35 participants, and Logistics with 23 participants. The function of the participants was aggregated into six categories. The smallest group in this category were CEO’s with 4 followed by scientists with 8 participants. A bigger proportion of the participants can be assigned to consultants (21) and managers (27). The two largest groups are executives (34) and employees (46). The hypotheses testing was done by a multiple regression to examine the relation between the identified critical success factors and associated benefits and challenges of the blockchain integration. Based on theoretical considerations three benefits or challenges each were assigned to one critical success factor, as result each regression consists of three independent variables and one dependent variable.

Empirical Results

First, it was examined if the exposed factors are considered for blockchain technology. To prove that a t-test was conducted. Since the Likert scale has a five-point level, the test value 3 was chosen. There was a significant effect for transparency $t(139) = 8.431$, $p < .001$ and speed $t(139) = 8.286$, $p < .001$ as well as complexity $t(139) = 9.066$, $p < .001$. The value for the factor cost $t(139) = 1.554$, $p = .122$ shows a weak significance. Data security $t(139) = 0.71$, $p = .479$ and digitalization $t(139) = -1.783$, $p = .077$ implement no significance. The results suggest that there are additional critical success factors beyond the exposed ones.

Despite the results of the t-test, all six hypotheses were analyzed with a multiple regression. As result H1 was accepted. Cost reduction is achieved by the blockchain integration through *low marginal cost*, *efficient management of inventory stocks* and *reduced paperwork* whereas the latter achieves the largest contribution to the explanation of the factor cost. This reflects the opinion of blockchain experts who imply that the blockchain enables to digitally track any kind of good and its information (Kim & Laskowski, 2016).

H3 stated that the blockchain integration fosters Speed by *reduced interactions* and *real-time exchange of information*. The results for this hypothesis are not in line with the recent research. Automatization such as processing a transaction can be completed with the inclusion in a block in minutes (Böhme et al., 2015). Especially the use of smart contracts, lead to an automatization where extensive documents need approval (Loop, 2016). This indicates that the selected feature automatization was not concrete enough to explain the factor speed.

In H6 need of digitalization for the blockchain integration are mostly influenced by the *availability of financial resources* and *integration of hardware components*. Due to the fact that the analysis depicted that *compatibility of software* has no influence on digitalization. This feature might not be important enough as long as the *availability of financial resources* is ensured which can be seen as not blockchain specific when it comes to investments for new technology. The results made clear that digitalization consists of more specific challenges than the three features used in this article.

The factor with the highest rated mean was transparency. This suggests that increased transparency in supply chain is the main expectation when integrating the blockchain. In contrary to this, H2 was rejected. Particularly, the *prevention from counterfeit goods* and *provenance of goods* could not be linked to the factor transparency although scientific literature and conducted case studies consider the prove of the real source of a good, certificate or process as very promising when it comes to transparency advantages for supply chain when using blockchain technology. An explanation might be that participants of the survey are not concerned about counterfeit and proof of goods.

The critical success factors complexity was also not explained by *compliance of standards*, *lack of required skills of the workforce*, and *missing identified applications* for the own business. It became clear that it is not sufficient to explain complexity with only three features. The factor itself needs to be broken down into more concrete terms of complexity because it is not just the technology which is difficult to understand and to develop, also the processes in which the technology is applied are complex (Casey & Wong, 2017).

Lastly, data security could not be related to the challenges *fear of privacy loss*, *lack of trust*, and *data manipulation*. The analysis implied that data manipulation has a high correlation with data security. Hence, the features need to be more specific when explaining data security. Furthermore, the level of data security depends on the blockchain's characteristic. A public, permissionless and distributed blockchain is due to the consensus-proof mechanism better protected against data manipulation then a centralized database (Schlatt et al., 2016).

Table 2: Data analysis results

Factor	Mean	Std. Deviation	Adjusted R Square	*F*	Sig.	Coefficients	Standardized Coefficient B	*t*	Sig.
Cost	3.14	1.033	.570	62.368	.000	low marginal costs	.313	4.771	.000
						reduced paperwork	.439	6.072	.000
						efficient inventory stocks	.161	2.319	.022
Transparency	3.84	1.173	.229	14.758	.000	prevention from counterfeit goods	-.271	-3.599	.000
						provenance of goods	-.075	-.948	.345
						improved analytics	.479	5.991	.000
Speed	3.77	1.102	.463	60.926	.000	reduced interactions	.408	5.408	.000
						real-time exchange of information	.367	4.867	.000
Complexity	3.73	.951	.155	9.523	.000	compliance of standards	-.083	-1.016	.311
						lack of required skills	.387	4.677	.000
						missing identified applications	-.001	-.012	.990
Data security	3.08	1.309	.511	49.483	.000	fear of privacy loss	.101	1.566	.120
						lack of trust	-.111	1.789	.076
						data manipulation	.702	10.538	.000
Digitalization	2.81	1.280	.333	24.168	.000	availability of financial resources	.368	4.395	.000
						compatibility of software	-.353	-3.585	.000
						integration of hardware	.528	5.432	.000

Conclusion

The purpose of this article was to point out what expectations about blockchain technology in the German logistics industry prevail. Therefore, a linkage between benefits and challenges of the blockchain integration and critical success factors of DSC was examined. The research question for this thesis was formulated as follows: What are the main critical success factors for the German logistics industry when integrating blockchain technology? The literature review exposed the critical success factors cost, transparency, speed, complexity, data security, and digitalization together with their benefits and challenges. From the description of the blockchain technology, the features of the blockchain were assigned to the critical success factors. It became clear how well those features meet the requirements of DSC. Hence, for every critical success factor a hypothesis was derived to test this affiliation.

Future research may explore those features within organizations through the use of open-ended or multiple-choice survey questions. This may result in reporting different benefits and challenges related to the blockchain integration that were not included in this research. Moreover, the article did not explore how organizations can integrate this technology within their supply chain. In this context, analyzing the blockchain integration best practices, recommending how to overcome implementation hurdles would be another future research. Additionally, it did not explore ways to overcome the presented challenges. Thus, further studies may examine this, too. Finally, this research was limited to individuals from the German logistics industry, who were partially not familiar with the blockchain topic. As time proceeds and more development of blockchain solutions are embraced the opinion of professionals who are likely to have direct involvement of the blockchain integration and operation may be considered. And, future research should capture expectations of participants from different countries.

The article offers insights on the expectations of supply chain practitioners about blockchain features. The elaborated features divided into benefits and challenges can be used in further surveys of blockchain research. Furthermore, the thesis provides starting points for future research to understand the contribution of blockchain technology to develop a digital supply chain.

Furthermore, it generates valuable insights for blockchain technology in the German logistics industry because both positive and negative expectations of possible adopters were pointed out. These insights are particularly valuable for those businesses that are offering blockchain solutions for that industry to recognize needs and deploy the right solutions. For example, blockchain provider can adjust their marketing activities on the outlined expectations.

Additionally, this study allows to draw conclusions relevant to blockchain integration for organizations and their supply chain. The exposed critical success factors serve as foundation for the development of blockchain solutions in organizations. Together with the corresponding benefits and challenges they can be used to assess one's own business and reveal possible applications. It supports managers to get to know potential benefits and challenges related to the blockchain that businesses are likely to face, internally and within their entire supply chain. It will help them to better comprehend the aspects that should be considered, and addressed in advance, within their initiatives and projects of the blockchain integration. Additionally, better strategic decisions can be made about acquiring the suitable technologies and external support required for the blockchain integration. This will result in optimizing operational performance by increasing the level of business competitiveness from integrating innovative technological solutions. This can be relevant information for managers to develop, promote and defend the acceptance of blockchain projects to overcome doubts about gained benefits, uncertain financial, social, and technical dimensions.

The focus of current blockchain research and development lies on the technical concerns and potentially business models. In contrast, this article contributes to what potential users expect from this new technology. The benefits and challenges examined could be partially assigned to the defined critical success factors. As a conclusion, it was exposed how blockchain technology can contribute to achieve a digital supply chain.

Bibliography

Akram, W. (2017). BLOCKCHAIN TECHNOLOGY: CHALLENGES AND FUTURE PROSPECTS. *International Journal of Advanced Research in Computer Science*, *8*(9), 642–644. https://doi.org/10.26483/ijarcs.v8i9.4950

Apte, S., & Petrovsky, N. (2016). Will blockchain technology revolutionize excipient supply chain management? *Journal of Excipients and Food Chemicals*, *7*(3), 76–78.

Bailey, G., Moss, C., & Whittaker, J. (2015). Digital Supply Chains: A Frontside Flip. Retrieved April 30, 2018, from https://www.thecge.net/web/viewer.html?file=/app/uploads/2016/09/FINAL-DSCiwhitepaper.pdf

Bailis, P., Narayanan, A., Miller, A., & Han, S. (2017). Research for practice: cryptocurrencies, blockchains, and smart contracts; hardware for deep learning. *Communications of the ACM*, *60*(5), 48–51. https://doi.org/10.1145/3024928

Beck, R., Avital, M., Rossi, M., & Thatcher, J. B. (2017). Blockchain Technology in Business and Information Systems Research. *Business & Information Systems Engineering*, *59*(6), 381–384. https://doi.org/10.1007/s12599-017-0505-1

Bentov, I., Gabizon, A., & Mizrahi, A. (2016). Cryptocurrencies Without Proof of Work. In J. Clark, S. Meiklejohn, P. Y. A. Ryan, D. Wallach, M. Brenner, & K. Rohloff (Eds.), *Financial Cryptography and Data Security* (Vol. 9604, pp. 142–157). Berlin, Heidelberg: Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-662-53357-4_10

Bhargava, B., Ranchal, R., & Ben Othmane, L. (2013). Secure information sharing in digital supply chains (pp. 1636–1640). Presented at the 3rd IEEE Int. Adv. Comput Conf., IEEE. https://doi.org/10.1109/IAdCC.2013.6514473

Bogart, S., & Rice, K. (2015). The blockchain report: welcome to the internet of value. Retrieved July 2, 2018, from https://needham.bluematrix.com/sellside/EmailDocViewer?encrypt= 4aaafaf1-d76e-4ee3-9406-7d0ad3c0d019&mime=pdf&co=needham&id= sbogart@needhamco.com&source=mail&utm_content=buffer0b432&utm_medium=social&utm_source=twitter.com&utm_campaign=buffer

Böhme, R., Christin, N., Edelman, B., & Moore, T. (2015). Bitcoin: Economics, Technology, and Governance. *Journal of Economic Perspectives*, *29*(2), 213–238. https://doi.org/10.1257/jep.29.2.213

Brühl, V. (2017). Bitcoins, Blockchain und Distributed Ledgers: Funktionsweise, Marktentwicklungen und Zukunftsperspektiven. *Wirtschaftsdienst*, *97*(2), 135–142. https://doi.org/10.1007/s10273-017-2096-3

Burgwinkel, D. (2016). Blockchaintechnologie und deren Funktionsweise verstehen. In D. Burgwinkel (Ed.), *Blockchain Technology*. Berlin, Boston: De Gruyter.

https://doi.org/10.1515/9783110488951-002

Büyüközkan, G., & Göcer, F. (2018). Digital Supply Chain: Literature review and a proposed framework for future research. *Computers in Industry*, (97), 157–177. https://doi.org/10.1016/j.compind.2018.02.010

Casey, M., & Wong, P. (2017). Global supply chains are about to get better, thanks to blockchain. *Harvard Business Review*, (13).

Christidis, K., & Devetsikiotis, M. (2016). Blockchains and Smart Contracts for the Internet of Things. *IEEE Access*, *4*, 2292–2303. https://doi.org/10.1109/ACCESS.2016.2566339

Clack, C. D., Bakshi, V. A., & Braine, L. (2016). Smart Contract Templates: foundations, design landscape and research directions. *ArXiv:1608.00771 [Cs]*. Retrieved July 4, 2018 from http://arxiv.org/abs/1608.00771

Condos, J., Sorrell, W. H., & Donegan, S. L. (2015). *Blockchain technology: Opportunities and risks*. Vermont.

Cong, L. W., & He, Z. (2017). Blockchain Disruption and Smart Contracts. Retrieved April 8, 2018 from http://dx.doi.org/10.2139/ssrn.2985764.

Crosby, M., Pattanayak, P., Verma, S., & Kalyanaraman, V. (2016). Blockchain Technology: Beyond Bitcoin. *Applied Innovation Review*, (2), 6–10.

Dijkman, R. M., Sprenkels, B., Peeters, T., & Janssen, A. (2005). Business models for the Internet of Things. *International Journal of Information Management*, *35*(6), 672–678.

Dweekat, A. J., Hwang, G., & Park, J. (2017). A supply chain performance measurement approach using the internet of things: Toward more practical SCPMS. *Industrial Management & Data Systems*, *117*(2), 267–286. https://doi.org/10.1108/IMDS-03-2016-0096

Farahani, P., Meier, C., & Wilke, J. (2017). Digital Supply Chain Management Agenda for the Automotive Supplier Industry. In G. Oswald & M. Kleinemeier (Eds.), *Shaping the Digital Enterprise* (pp. 157–172). Cham: Springer International Publishing. https://doi.org/10.1007/978-3-319-40967-2_8

Ferretti, M., & Schiavone, F. (2016). Internet of Things and business processes redesign in seaports: The case of Hamburg. *Business Process Management Journal*, *22*(2), 271–284. https://doi.org/10.1108/BPMJ-05-2015-0079

Francisco, K., & Swanson, D. (2018). The Supply Chain Has No Clothes: Technology Adoption of Blockchain for Supply Chain Transparency. *Logistics*, *2*(1), 2. https://doi.org/10.3390/logistics2010002

Franke, U., Engelbrecht, A., & Heinert, S. (2018). *Blockchain in Procurement & SCM*. Institute for supply chain security. Webinar from June 21, 2018.

Gimpel, H., & Röglinger, M. (2017). Disruptive Technologien — Blockchain, Deep Learning & Co. *Wirtschaftsinformatik & Management*, *9*(5), 8–15. https://doi.org/10.1007/s35764-017-0103-5

Greenspan, G. (2015). Avoiding the pointless blockchain project. Retrieved April 11, 2018, from https://www.multichain.com/blog/2015/11/avoiding-pointless-blockchain-project/

Groenfeldt, T. (2017). IBM and Maersk apply blockchain to container shipping. Retrieved July 4, 2018, from https://www. forbes. com/sites/tomgroenfeldt/2017/03/05/ibm-and-maersk-apply-blockchain-to-container-shipping

Hackius, N., & Petersen, M. (2017). Blockchain in logistics and supply chain : trick or treat? In W. Kersten, T. Blecker, & C. M. Ringle (Eds.). Presented at the Hamburg International Conference of Logistics (HICL) 2017. https://doi.org/10.15480/882.1444

Hanifan, G., Sharma, A., & Newberry, C. (2014). *The Digital Supply Network: A new paradigm for supply chain management*. Accenture. Retrieved May 8, 2018 from https://www.accenture.com/t20150708T025455__w__/fr-fr/_acnmedia/Accenture/Conversion-Assets/DotCom/Documents/Local/fr-fr/PDF_5/Accenture-Digital-Supply-Network-New-Standard-Modern-Supply-Chain-Management.pdf

Hegadekatti, K. (2016). Analysis of Contracts in Various Formats of Blockchain. MPRA Paper No. 82868. Retrieved April 8, 2018 from https://mpra.ub.uni-muenchen.de/82868/.

Hopf, S., & Picot, A. (2018). Revolutioniert Blockchain-Technologie das Management von Eigentumsrechten und Transaktionskosten? In T. Redlich, M. Moritz, & J. P. Wulfsberg (Eds.), *Interdisziplinäre Perspektiven zur Zukunft der Wertschöpfung* (pp. 109–119). Wiesbaden: Springer Fachmedien Wiesbaden. https://doi.org/10.1007/978-3-658-20265-1_9

Hussain, M. I. (2017). Internet of Things: challenges and research opportunities. *CSI Transactions on ICT*, *5*(1), 87–95. https://doi.org/10.1007/s40012-016-0136-6

Kamath, R. (2018). Food Traceability on Blockchain: Walmart's Pork and Mango Pilots with IBM. *The Journal of the British Blockchain Association*, *1*(1), 1–12. https://doi.org/10.31585/jbba-1-1-(10)2018

Kim, H. M., & Laskowski, M. (2016). Towards an Ontology-Driven Blockchain Design for Supply Chain Provenance. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.2828369

Kiviat, T. I. (2015). Beyond Bitcoin: Issues in Regulating Blockchain Transactions. *DUKE LAW JOURNAL*, *65*, 40.

Klapdor, M. (2018). Herausforderungen QOS: Chancen und Herausforderungen der Blockchain. *Digitale Welt*, *2*(2), 66–67. https://doi.org/10.1007/s42354-018-0084-4

Kolain, M. (2017). Die Blockchain als »vollkommenes Gesetzbuch«? Rechtshistorische Überlegungen zur Konfliktlösung in Smart Contracts. In H. Hill, D. Kugelmann, & M. Martini (Eds.), *Perspektiven der digitalen Lebenswelt* (pp. 147–162). Nomos Verlagsgesellschaft mbH & Co. KG. https://doi.org/10.5771/9783845283982-147

Kõlvart, M., Poola, M., & Rull, A. (2016). Smart Contracts. In T. Kerikmäe & A. Rull (Eds.), *The Future of Law and eTechnologies* (pp. 133–147). Cham: Springer International Publishing. https://doi.org/10.1007/978-3-319-26896-5_7

Kshetri, N. (2018). Blockchain's roles in meeting key supply chain management objectives. *International Journal of Information Management*, (39), 80–89.

Kumar, V., Amorim, M., Bhattacharya, A., & Garza-Reyes, J. A. (2016). Managing reverse exchanges in service supply chains. *Supply Chain Management: An International Journal*, *21*(2), 157–165. https://doi.org/10.1108/SCM-12-2015-0467

Kümmerlen, V. R. (2018). Blockchain braucht noch viel Zeit, *Deutsche Verkehrs-Zeitung* (10), 2.

Lee, I., & Lee, K. (2015). The Internet of Things (IoT): Applications, investments, and challenges for enterprises. *Business Horizons*, *58*(4), 431–440. https://doi.org/10.1016/j.bushor.2015.03.008

Li, B., & Li, Y. (2017). Internet of Things drives supply chain innovation: a research framework. *International Journal of Organizational Innovation*, *9*(3), 71–92.

Lomas, N. (2015). Everledger is using blockchain to combat fraud, starting with diamonds. Retrieved July 4, 2018, from https://techcrunch. com/2015/06/29/everledger.

Loop, P. (2016). Blockchain: The next evolution of supply chain. *Material Handling & Logistics*, pp. 22–24.

Mann, J. (2015). The Internet of Things: Opportunities and applications across industries. *International Institute for Analytics, Enterprise Research Service*.

Mattila, J., Seppälä, T., & Holmström, J. (2016). Product-centric Information Management: A Case Study of a Shared Platform with Blockchain Technology. Presented at the Industry Studies Association Conference, Minneapolis, MN, USA. Retrieved April 8, 2018 from https://escholarship.org/uc/item/65s5s4b2

Morabito, V. (2017). *Business Innovation Through Blockchain*. Cham: Springer International Publishing. https://doi.org/10.1007/978-3-319-48478-5

Penthin, S., & Dillman, R. (2015). *Digital SCM* (A BearingPoint Accelerator). BearingPoint. Retrieved May 8, 2018, from https://www.bearingpoint.com/files/BearingPoint-Digital-Supply-Chain-Management.pdf&download=0

Peters, G., & Panayi, E. (2015). Understanding Modern Banking Ledgers Through Blockchain Technologies: Future of Transaction Processing and Smart Contracts on the Internet of Money. Retrieved June 21, 2018, from https://dx.doi.org/10.2139/ssrn.2692487

Pfisterer, D., Radonjic-Simic, M., & Reichwald, J. (2016). Business Model Design and Architecture for the Internet of Everything. *Journal of Sensor and Actuator Networks*, *5*(2), 7. https://doi.org/10.3390/jsan5020007

Raab, M., Griffin-Cryan, B., Nelles, J., Roussie, R., Wilson, S., & van Tolder, T. (2011). *Digital Supply Chain Transformation: Crating Value - When digital meets physical*. Retrieved April 30, 2018, from https://www.capgemini.com/wp-content/uploads/2017/07/Digital_Transformation_of_Supply_Chains.pdf

Reaidy, P. J., Gunasekaran, A., & Spalanzani, A. (2015). Bottom-up approach based on Internet of Things for order fulfillment in a collaborative warehousing environment. *International Journal of Production Economics*, (159), 29–40. https://doi.org/10.1016/j.ijpe.2014.02.017

Riggins, F. J., & Wamba, S. F. (2015). Research Directions on the Adoption, Usage, and Impact of the Internet of Things through the Use of Big Data Analytics (pp. 1531–1540). IEEE. https://doi.org/10.1109/HICSS.2015.186

Ryan, P., & Watson, R. (2017). Research Challenges for the Internet of Things: What Role Can OR Play? *Systems*, *5*(1), 24. https://doi.org/10.3390/systems5010024

Schlatt, V., Schweizer, A., Urbach, N., & Fridgen, G. (2016). Blockchain: Grundlagen, Anwendungen und Potenziale. *Fraunhofer FIT*, 1–54.

Schmidt, B., Rutkowsky, S., Petersen, I., Klötzke, F., Wallenburg, C. M., & Einmahl, L. (2015). *Digital Supply Chains: Increasingly Critical for Competitive Edge* (Logistics Study 2015 No. 7). A.T. Kearny/WHU. Retrieved April 30, 2018, from https://www.atkearney.com/documents/20152/435077/Digital%2BSupply%2BChains.pdf/82bf637e-bfa9-5922-ce03-866b7b17a492

Schrauf, S., & Berttram, P. (2016). *Industry 4.0: How digitization makes the supply chain more efficient, agile, and customer focused*. Strategy&. Retrieved May 9, 2018, from https://www.strategyand.pwc.com/media/file/Industry4.0.pdf

Seebacher, S., & Schüritz, R. (2017). Blockchain Technology as an Enabler of Service Systems: A Structured Literature Review. In S. Za, M. Drăgoicea, & M. Cavallari (Eds.), *Exploring Services Science* (Vol. 279, pp. 12–23). Cham: Springer International Publishing. https://doi.org/10.1007/978-3-319-56925-3_2

Seidel, H., & Kutzler, T. (2014). Digitale Logistik als Wegbereiter für Cloud-basierte Dienste in der Logistik. *Wirtschaftsinformatik & Management*, *6*(1), 78–86. https://doi.org/10.1365/s35764-014-0387-7

Skwarek, V. (2017). Blockchains as security-enabler for industrial IoT-applications. *Asia Pacific Journal of Innovation and Entrepreneurship*, *11*(3), 301–311. https://doi.org/10.1108/APJIE-12-2017-035

Stankovic, J. A. (2014). Research Directions for the Internet of Things. *IEEE Internet of Things Journal*, *1*(1), 3–9. https://doi.org/10.1109/JIOT.2014.2312291

Staples, M., Chen, S., Falamaki, S., Ponomarev, A., Rimba, P., Tran, A. B., … Zhu, J. (2017). *Risks and opportunities for systems using blockchain and smart contracts*. Data61(CSIRO).

Swan, M. (2015). Blockchain Thinking: The Brain as a DAC (Decentralized Autonomous Organization). Retrieved from https://pdfs.semanticscholar.org/ac86/2c394d5233d7fea85cdf45848b354b0a12b4.pdf

Swanson, T. (2014). Great chain of numbers: A guide to smart contracts, smart property and trustless asset management. *Amazon Digital Services.*

Tu, M., Lim, M. K., & Yang, M.-F. (2018). IoT-based production logistics and supply chain system – Part 1: Modeling IoT-based manufacturing supply chain. *Industrial Management & Data Systems*, *118*(1), 65–95. https://doi.org/10.1108/IMDS-11-2016-0503

Tuesta, D., Alonso, J., & Camara, N. (2015). Smart contracts: The ultimate automation of trust. *Digital Economy Outlook, October 2015*.

Uddin, S., & Sharif, A. A. A. A. (2016). Integrating Internet of Things with maintenance spare parts' supply chain (pp. 1–4). IEEE. https://doi.org/10.1109/ICEDSA.2016.7818491

Van de Velde, J., Scott, A., Sartorius, K., Dalton, I., Shepherd, B., Allchin, C., … Rennick, E.

(2016). Blockchain in Capital Markets: The prize and the journey. *Euroclear Group and Oliver Wyman.*

Walport, M. G. C. S. A. (2016). *Distributed ledger technology: Beyond blockchain*. UK Government Office for Science.

Welzel, C., Eckert, K.-P., Kirstein, F., & Jacumeit, V. (2017). *Mythos Blockchain: Herausforderung für den Öffentlichen Sektor*. Berlin: Kompetenzzentrum Öffentliche IT Fraunhofer-Institut für Offene Kommunikationssysteme FOKUS.

Whitmore, A., Agarwal, A., & Da Xu, L. (2015). The Internet of Things—A survey of topics and trends. *Information Systems Frontiers*, *17*(2), 261–274. https://doi.org/10.1007/s10796-014-9489-2

Xu, J. (2014). *Managing Digital Enterprise - Ten essential topics.* Paris: Atlantis Press. Retrieved May 8, 2018, from https://books.google.de/books?hl=de&lr=&id=CwDIBAAAQBAJ&oi=fnd&pg=PR5&dq=xu+managing+digital+enterprise&ots=zcxCBQU7kX&sig=y5oUcK5TxU21T5kfvwoOr0rOUaU#v=onepage&q=xu%20managing%20digital%20enterprise&f=false

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), e0163477. https://doi.org/10.1371/journal.pone.0163477