



HAL
open science

Blockchain Implementation Process Model for Supply Chains - From Technology Awareness to Scaling

Marc Hübschke, Eugen Buss, Stefan Lier, Elmar Holschbach

► **To cite this version:**

Marc Hübschke, Eugen Buss, Stefan Lier, Elmar Holschbach. Blockchain Implementation Process Model for Supply Chains - From Technology Awareness to Scaling. 23th Working Conference on Virtual Enterprises (PRO-VE), Sep 2022, Lisbon, Portugal. pp.447-460, 10.1007/978-3-031-14844-6_36 . hal-04642027

HAL Id: hal-04642027

<https://inria.hal.science/hal-04642027v1>

Submitted on 9 Jul 2024

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons Attribution 4.0 International License



This document is the original author manuscript of a paper submitted to an IFIP conference proceedings or other IFIP publication by Springer Nature. As such, there may be some differences in the official published version of the paper. Such differences, if any, are usually due to reformatting during preparation for publication or minor corrections made by the author(s) during final proofreading of the publication manuscript.

Blockchain Implementation Process Model for Supply Chains - From Technology Awareness to Scaling

Marc Hübschke, Eugen Buss, Stefan Lier, Elmar Holschbach

Dep. of Engineering and Business Administration, South Westphalia University of Applied Sciences, Meschede, Germany
{huebschke.marc@fh-swf.de, buss.eugen@fh-swf.de, lier.stefan@fh-swf.de, holschbach.elmar@fh-swf.de}

Abstract. This contribution proposes a new blockchain implementation process model which closes identified gaps of existing models such as the lack of supply chain management focus, guidance on scaling or performance measurement. In particular, existing models do not provide a sufficiently detailed approach. To prove this, we develop criteria for a blockchain implementation process model in supply chains and systematically compare existing process models in this context. In order to identify a suitable use case for companies, to plan its implementation and to measure its impact on the company performance, we develop a new implementation process model. Furthermore, this process model supports the roll-out of the blockchain use case to other partners along the value chain, thereby increasing scalability.

Keywords: Blockchain, Blockchain implementation process model, Supply Chain Management

1 Introduction

Companies operating in globalized supply chain networks experience increasing competitive pressure driven by an accelerated business pace [1]. A large amount of data is exchanged along the supply chain, but there is often a lack of trust between the parties involved [2]. Companies are concerned that information could be leaked to a competitor or company confidential information could be made public. This leads to data exchange being prevented and to some information received not being trusted. In this context, blockchain technology has the potential to simplify collaboration in supply chain networks by addressing the trust issues between the stakeholders [3]. Blockchain technology is one of today's most promising technological innovations and, due to its characteristics, provides many advantages, especially in supply chain management [4,5]. Some of its benefits include data integrity through immutability of information, network resilience through decentralized structures, cost reduction due to process automation and secure as well as transparent supply chain data exchange among companies [6,7]. Despite these numerous advantages and exploitable potentials, only a few companies have used the technology yet. Small and medium-sized enterprises (SME) in particular are reluctant to use the technology due to

existing barriers. A detailed literature review has shown that no holistic blockchain implementation model exists offering companies a step-by-step guide from the initial idea of the blockchain to the identification of a suitable use case and then to actual implementation and scaling. The objective of this paper is to develop a model for the integration of blockchain technology in companies and in particular small and medium sized enterprises for supply chain management.

2 Background

In this section, the relevant theoretical backgrounds such as supply chain management and blockchain technology including their definitions are introduced to achieve a common understanding.

2.1 Supply Chain Management

According to the Council of Supply Chain Management Professional (CSMCP), supply chain management (SCM) is defined as the planning and management of all activities involved in sourcing and procurement, conversion and other logistics management activities. This essentially includes coordination and collaboration with partners, which can be suppliers, intermediaries, third-party providers and customers [8]. The main objective of supply chain management, according to Muchna et al., is to use information and coordination mechanisms to manage supply chain processes in such a way that supply and demand are synchronized as much as possible [9]. As a result of an increasing division of labor, supply chain networks are becoming more and more complex [9] leading to our current day situation where it is not individual companies, but rather entire supply chain networks are competing with each other [9]. The reciprocal exchange of information between supply chain participants is recognized not only as a crucial activity of SCM [10], but also as the management of these networks [11]. Sharing information is essential to ensure coordination among partners, build an integrated supply chain and meet customer demands [12]. The reciprocal sharing of information such as forecasts, inventory levels and track-and-trace data reduces uncertainty amongst supply chain partners and can finally create a more effective supply chain [13].

2.2 Blockchain in Supply Chain Management

For the supply chain management and related collaborative information, sharing is important. Increasing this can significantly improve the efficiency of supply chains [14]. Companies often share only a certain amount of information with each other because of concerns about other partners in the supply chain [15]. To strengthen collaboration, blockchain provides a secure, more direct and decentralized infrastructure even in non-trusted environments [15]. According to Lee Kuo Chuen,

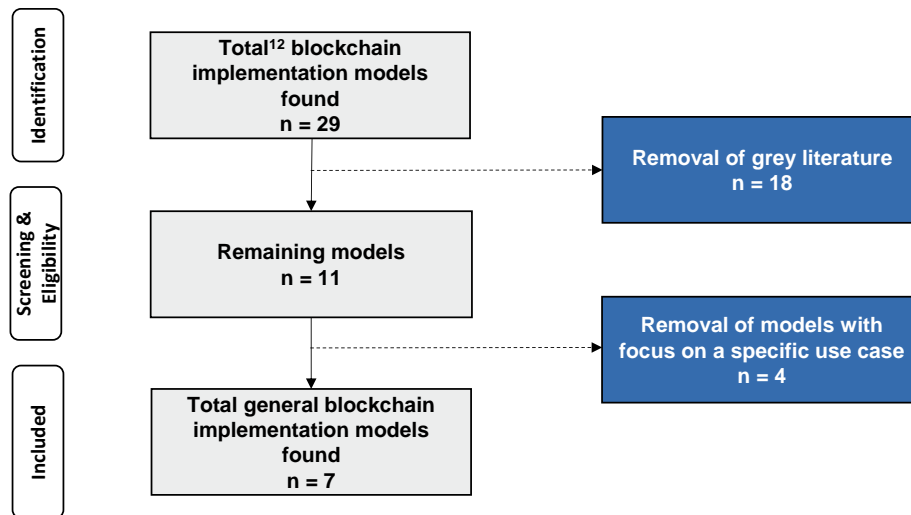
the blockchain can be defined as a decentralized, constantly growing list of entries, called blocks, which are interconnected in an equal network and secured by cryptography. To form a network or chain, each block contains a cryptographic hash of the previous block with a timestamp and transaction data, as well as information of all previous blocks and transactions. Once the information has been processed by the blockchain, all computers in the network lock in. At the same time, a permanent digital record is created that is hard to alter [16]. Most blockchains today include smart contracts that allow business logic to be implemented [17]. This enables complex applications and services between users [17]. The technical architecture of the blockchain offers several advantages. These include tamper resistance, transparency through chronological storage, reduction of transaction costs through intermediation, automation of processes with smart contracts and high network resilience [15]. This results in a broad field of application for supply chain management. Among the most important applications of blockchain in supply chain management are easing paperwork processes, identifying counterfeit products, facilitating tracking and tracing, and monitoring the condition of products through the internet of things [18]. Despite the opportunities that blockchain offers for supply chain management, they often cannot be exploited. Companies, and small and medium size enterprises in particular, have difficulties in adopting and implementing blockchain technology [19]. The reasons for this are manifold. Many managers lack a strong knowledge of the technology and its possibilities [20]. Furthermore, the impact of the technology on all areas is not predictable [17]. To take advantage of the benefits, the supply chain network should be extensive. In this context, one of the biggest challenges of a successful use case with blockchain is scaling [21].

3 Methodology

A large number of Blockchain implementation models already exists in the academia. For this reason, a literature research and analysis of existing models will be conducted to obtain an overview. This literature analysis is conducted according to Webster & Watson (2002) [22]. For the research the databases IEEE, Web of Science, Elsevier, Scopus, Springer Link and Google Scholar were used. The basic requirement is that the models are written in the English or German language.

In the first step, a list of the blockchain implementation models found has been created. A total of 29 different models have been found whose focus is on the introduction of blockchain technology in businesses. To generate high scientific standard peer-reviewed articles are prioritized in the selection of articles, but to obtain a wider range of models relevant to practice, models in scientific textbooks are also included. Gray literature is excluded because it does not fulfill the scientific standard due to a lack of peer reviews or originates from companies with commercial interests and is often not described in detail. In addition, these are not listed in common databases. Eleven models remain. In the next step, all models are filtered out that are not generally applicable but relate to a specific use case (e.g. electronic voting system

or energy sector). In total, there are seven models that relate to the general adoption of blockchain in enterprises. Figure 1 shows the literature selection procedure in detail black and white.



¹ databases: IEEE, Web of Science, Elsevier, Scopus, Springer Link, Google Scholar

² search strings: Blockchain Process Model, Blockchain Implementation Model, Blockchain Process Implementation Model, Blockchain Model, Blockchain Supply Chain Process Model, Blockchain Step-by-step-guide

Fig 1: Overview of the literature selection process

3.1 Existing Blockchain Implementation Models

The remaining seven identified process models are the subject of analysis in this paper. These are the following process models:

1. Model for integrating blockchain technology in supply chain according to Guerpinar et al. [23]
2. Path to blockchain enterprise adoption according to Arun et al. [24]
3. Blockchain implementation phases according to Attaran and Gunasekaran [25]
4. Selection process to identify application opportunities for blockchain technology according to Werner et al. [26]
5. Three pillars for realizing a successful blockchain use case according to Urban [27]

6. Process model for the implementation of blockchain in companies according to Wittenberg [6]
7. Conceptual stage model for blockchain implementation in Supply Chains according to Vu et al. [28]

The first model consists of six phases defining multiple activities and milestones [23]. The model framework covers the whole process starting with the evaluation of the use case and ending with the evaluation of the implementation results. A special characteristic of the model is that the processes are partly executed iteratively and that repetitive cross functions are described. Arun's et al. model describes four phases from use case identification to enterprise integration. Specific activities are also defined within the model [24]. The Blockchain implementation phases model according to Attaran and Gunasekaran contains three phases also starting with the finding of a suitable use case and ending with the implementation in the company. The authors also mentioned the importance of continuous improvement afterwards [25]. According to Werner et al. two different stages are to be considered: The selection of the use case and the implementation afterwards. These two phases are enriched by several phases [26]. Urban's model consists of three pillars each defining a different model starting with the first idea of implementation and finishing with the integration of blockchain in future usage [27]. Wittenberg's model consists of four different phases with each model defining a milestone after completing the activities. The model analyses the whole process from finding a suitable use case to maintaining the implemented blockchain solution inside the company [6]. Due to Vu et al. three stages with different factors need to be taken into account when implementing a blockchain. These factors need to be considered in each phase making the model also iterative. The model starts with the initiation and ends with the implementation [28].

3.2 Requirements for Blockchain Implementation Models

This section, we highlight requirements from the literature for a process model for blockchain implementation. Five requirements (**RQ**) emerged from a combination of different research. First, they originate from the project experience of an ongoing Blockchain implementation project. In addition to this, the requirements have been included from discussions with German small and medium sized enterprises at various events, which thereby have a high practical relevance. This is due to the high density of hidden champions in the North Rhine-Westphalia region, which is representative of small and medium-sized enterprises in Germany. The listed requirements do not claim to be complete and represent a current status at the time of publication. These requirements are briefly described below, based on the literature:

RQ1 Creating a technology insight: For many companies and in particular SMEs, blockchain is an innovative but also complex technology [27,29]. In order to develop and subsequently implement suitable use cases, both the opportunities and the limitations of the technology should be fundamentally understood [20,21,29]. In

addition, when designing your own use cases, you benefit from knowing about existing use cases. The results must be easy to understand so that they can also be discussed in interdisciplinary teams [30].

RQ2 Holistic perspective: The second requirement is a holistic perspective on implementation. In this paper, we understand holistic perspective on the one hand as a socio-technical perspective, with the consideration of technical and organizational aspects and the human factor and their interactions, as generally recommended for digitization projects [31]. The organizational aspects include processes and responsibilities in companies [32]. The technical aspects involve systems and interfaces, data standards, a smart contract concept and permissions [23]. For the human factor, competencies and work routines must be considered and onboarding focused [33-34]. In addition, legal [21], [25] ecological [35-36] and strategic aspects [37-38] should also be taken into consideration in order to gain a holistic perspective.

RQ3 Iterative and agile approach: In IT project management, agile methods are regularly used in an iterative way [39]. These methods combine speed with flexibility and can react effectively to changing requirements [40]. Guerpinar et al. also take this into account in their implementation model by allowing phases to take place repeatedly [23]. During development, a simple result should be aimed for as a minimum viable product [6], [41]. Feedback should be allowed and taken into account at every stage [23].

RQ4 Impact analysis and performance measurement: The frequently assumed disruptive character of blockchain is based on its fundamental changes for companies, their value creation and their business model [42]. In order to successfully roll out blockchain, Dutta et al. recommend detailed analysis of the impact on the company and its supply chain [43]. The use of qualitative (e.g. improvement of transparency) and quantitative methods [6], [27], [44-45] for performance measurement should also be considered during implementation. This requires the determination of the impact on all areas according to RQ2 and a method-based detailed analysis depending on the area.

RQ5 Scaling to further business partners: In supply chains, value creation is achieved across multiple companies [46] and requires optimized information flows in addition to optimized material and cash flows [9]. Therefore, supply chain management is the collaboration of companies to fulfill customer needs [47]. If blockchain is used as an infrastructure for the exchange of information and intangible assets, it requires a sufficient number of participating companies. Blockchain will strengthen supply chain management when sufficient scale has been achieved [21], [46]. For this purpose, partners have to be evaluated according to their maturity level (e.g. business relationships, contacts, similar use case) and afterwards the network can be expanded.

4 Evaluation

In the following, the process models for implementation selected in section 3.1 are compared with the requirements identified in section 3.2. Each of the process models has been evaluated along the guiding question "To what extent does the process model in the row meet the requirements of the column?". The evaluation examines whether a model fulfills the respective requirement. The evaluation indicates "fulfilled", "partially fulfilled" and "not fulfilled", but no process model completely fulfills a requirement. The entire evaluation is shown in Figure 2.

Evaluation of the researched approaches according to the set requirements. Question: To which extent does the researched approach in the row meet the requirements of the process model in the column? Rating scale: <input type="radio"/> = not fulfilled <input type="radio"/> = partially fulfilled <input checked="" type="radio"/> = fulfilled	Requirements (RQ)				
	Creating a technology insight	Holistic perspective	Iterative and agile approach	Impact analysis and performance measurement	Scaling to further business partners
	RQ1	RQ2	RQ3	RQ4	RQ5
Model for integrating blockchain technology in supply chain according to Gürpınar et al.	<input type="radio"/>	<input checked="" type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
Path to blockchain enterprise adoption according to Arun et al.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Blockchain implementation phases according to Attaran and Gunasekaran	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Selection process to identify application opportunities for blockchain technology according to Werner et al.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Three pillars for realizing a successful blockchain use case according to Urban	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
Process model for the implementation of blockchain in companies according to Wittenberg	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
Conceptual stage model for Blockchain implementation in Supply Chains according to Vu et al.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Fig 2: Evaluation of the analyzed models in terms of the requirements for the implementation of blockchain technology in enterprises

The requirement **RQ1** "Creating a technology insight" is partially fulfilled by four process models and not fulfilled by the remaining models. All process models start with either the identification of a use case or an evaluation of it. A specific phase for providing BC knowledge is not found in any model. The process model according to Attaran and Gunasekaran partially fulfills the requirement because questions about their current business model are used to familiarize managers with the technology [25]. Urban gives BC knowledge using a self-developed and detailed decision model for the use of the technology and shows alternatives when a BC is not suitable [27]. Starting with an open collection of use cases, these are evaluated according to Werner et al. and the list is gradually reduced until only one suitable use case remains. The reduction follows an evaluation and examination of the use case. In workshops, basic knowledge is thus provided through iterations [26]. Vu et al. identify a lack of knowledge as a barrier to successful implementation and highlight this as a task in their initiation phase [28]. How they provide this knowledge is not described in detail.

The second requirement (**RQ2**) is partially fulfilled by every process model, since at least one process and one technology perspective are always taken into account during implementation. Only three models fulfill this requirement in its entirety and consider the levels of people, organization and processes. These three process models have certain aspects that they particularly emphasize. Wittenberg, for example, also considers the legal aspects [6]. In contrast, Guerpinar et al.'s process model focuses on the human factor in addition to organizational aspects during the integration phase [23]. Attaran and Gunasekaran also include all levels and provide a very detailed description of them [25].

Only one of the process models follows an iterative and agile approach according to **RQ3**, two others in divisional, while the other process models are executed linearly, phase by phase. The process model of Guerpinar et al. as the only one has an iterative continuous improvement and support phase and goes through its first preliminary phase once and therefore defines the use case in general terms. Each subsequent phase can be cycled to continuously gather feedback and make necessary changes [23]. As described above, Werner et al. approach the most appropriate use case iteratively [26] in their process model, while implementation is linear without feedback. Wittenberg uses agile IT project management methods in his process model to develop and improve the prototype. Before the prototype goes live, it is tested repeatedly [6]. There is no loop back to a previous phase in the model.

An impact analysis and performance measurement (**RQ4**) are a prerequisite for evaluating the implementation. Only two of seven process models fulfill this requirement. Both Wittenberg and Urban use scoring models [6], [27] to determine the value added by the Blockchain. They visualize the new business relationships using either BPMN or their own representation consisting of material flows, cash flows, and information flows [6], [27]. Guerpinar et al. is the only process model with an additional quantitative analysis approach, but it is not described in detail and for this reason is only classified as partially fulfilled [23].

The fifth requirement "Scaling to further business partners" (**RQ5**) is only partially fulfilled by two process models. While the remaining process models state the

importance of scaling, they do not provide any information on its achievement and conclude with implementation [6], [24-27]. Guerpinar et al. include the scalability of the use case in their integration planning phase in order to minimize the effort involved in transferring it to further partners [23]. By analogy with Guerpinar et al., Vu et al. refer to so-called system-related barriers in their initiation phase, which also include scalability. A detailed description of how scaling can succeed is missing [28]. A subsequent phase for scaling the blockchain solution is missing in all process models. After comparing the process models with the identified requirements, it can be concluded that no existing process model fulfills all requirements. Consequently, a new process model needs to be developed that meets these requirements.

5 Results

In the following section, the developed blockchain implementation model is presented in detail including the individual tasks and results. This model is intended to provide companies with a step-by-step guide to overcome the barrier of blockchain adoption and accelerate digitization. Especially for small and medium-sized enterprises, which have great difficulties with such complex projects. Figure 3 shows the model in its completeness:

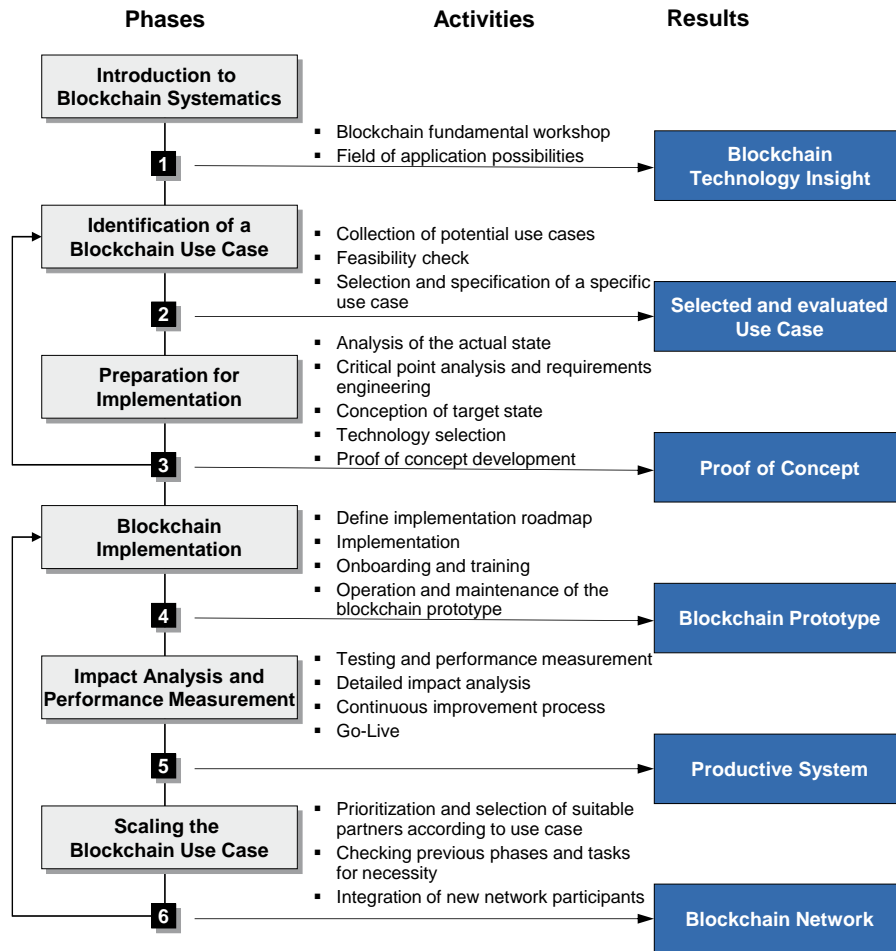


Fig 3: Blockchain implementation process model for supply chains

The first phase of the model is called introduction to blockchain systematics. The purpose of this phase is to gain a deeper understanding of blockchain technology, as this knowledge is essential for selecting a suitable use case. Only if the basics are understood it is possible to build a custom use case. Therefore, the use of experiential knowledge is particularly important. This understanding will be provided during workshops. In addition, possible application fields are examined with best practices based on already existing use cases. The result after completion of the first phase is a Blockchain Technology Insight and therefore the fulfillment of the first requirement (RQ1).

In the second phase, the blockchain use case is identified. For this process, potential use cases are collected in the company using creativity techniques (e.g., brainstorming). The use cases are subsequently examined in detail for technical,

economic and legal feasibility. Once a use case has been found, it is specified in precise terms. An assessment framework is developed for this purpose. This is used to evaluate, for example, compatibility with the existing business model, the expected economic benefit and the non-economic benefit (e.g. increased transparency). The assessment framework can be designed for the following three use case dimensions: Data, Processes, and Systems. All information is described in a formalized way in a Blockchain Canvas. Possible content includes which blockchain system should be used, which supply chain partner should participate, and which technology should be used as a complementary tool (e.g., Internet of Things). The second phase allows the model to also fulfil the second Requirement (**RQ2**), the holistic perspective. The result is a selected and evaluated Use Case.

Once the second phase has been completed, the third phase starts: Preparation for Implementation. The focus is on the current state of the existing process and IT landscape. At the same time, the processes are operationalized and enhanced with costs, times, participants and, if necessary, CO₂ consumption. The IT systems are expanded to include data, data standards, interfaces and other relevant information. The analysis of the current situation takes a socio-technical approach which considers technology, people and organization. Afterwards, a weak point analysis and requirements elicitation with success factors are carried out. The final step is the design of the target state with the blockchain solution as an implementation roadmap for the company. This includes the proof of concept development. The result of this phase is the proof of concept. However, if no applicable use case has been found in this phase, phases two and three are iteratively repeated until this is done. Thereafter, the fourth phase starts.

This fourth phase is called blockchain implementation and aims to develop a Blockchain prototype. For this purpose, the right Blockchain technology is selected according to the previously identified requirements. Depending on the use case and the specific demands, there are three types of Blockchains to choose from: Private, Public and Permissioned. In the same way, the roles and permissions in the network are defined. This includes assigning read and write permissions, deciding which data should be stored on-chain and which off-chain, and allocating responsibilities. Once the prototype is developed, it will be implemented and onboarding for the employees will take place. If errors occur during user training, they must be corrected before commissioning. The operation and maintenance of the blockchain prototype are also tasks in this phase. The result is the finished blockchain prototype.

In the fifth phase (impact analysis and performance measurement), the focus is on measuring success according to fulfilled requirements and defined success factors. Examples of success factors are the usability and graphical user interface of the prototype, the increase in efficiency that has been achieved and cost and energy savings. Another particularly important aspect of this phase is the comparison of target and actual processes. A GAP analysis is used for this purpose. The gaps identified from the analysis are worked out in detail. The whole process takes place as a continuous improvement process. Finally, a deduction and definition of measures

for improvement potentials takes place. With the go live the result of this phase is the finished productive system. Through a detailed performance measurement, impact analysis and a multi-method approach, the model also fulfills the requirement **RQ4**.

The final phase of the model is scaling the blockchain use case. During this phase, the company has to decide how to scale the network. The question must be answered in which order which customer or supplier should be added to the Blockchain network. A strategy also needs to be developed as to how the customers of the customers and the suppliers of the suppliers can be integrated. In the process of connecting new partners, it is important to check which phases in the model need to be iterated again. Phases one to three are skipped because a productive system is already in place and only the network needs to be expanded. Accordingly, an iteration also takes place in this last phase. It is also necessary to check whether there are any termination criteria for the connection of new partners. After the successful connection of business partners, the result at the end of the phase is the finished blockchain network. The last phase of the model leads to the fulfillment of requirements **RQ3** (iterative approach) and **RQ5** (scaling to further business partners). Therefore, the model fulfills all requirements for a Blockchain implementation model and advances both science and practice.

6 Conclusion

An increasing challenge in supply chain management is the exchange of information. Global division of labor is creating supply chain networks rather than individual supply chains. It is the supply chain networks and not the individual companies that are competing against one another, and they are competitive when the exchange of information between the individual companies is efficient. Blockchain technology provides an approach to transmit information rapidly, encrypted and tamper-proof within the supply chain. Currently, small and medium sized enterprises in particular struggle with the implementation of blockchain technology, as it is an extremely complex technology. To simplify the implementation for companies, a large amount of blockchain implementation models can be found. In a comprehensive literature review, the existing models were compiled and analyzed. Subsequently, five requirements were identified from the literature, from project experience with SMEs and from discussions with companies, which apply to blockchain implementation models. The collected models were compared and evaluated based on the requirements. The result is as follows: while none of the models meets all the requirements, some of them meet them partially and others do not meet them at all. Therefore, a model for the introduction of blockchain technology is developed that fulfills all the five requirements. This model is intended to provide companies with a guideline for the implementation of blockchain technology, starting with the identification of a use case and ending with the scaling to other business partners and post-implementation monitoring.

Based on this study, it is necessary to examine if the implementation model also leads to positive results in practice. For this purpose, at least partial aspects of it should be implemented, evaluated and continuously developed further at the beginning. Several German SMEs have agreed to participate in the evaluation and subsequent validation after implementation of the process model. The findings and requirements collected will also be validated by experts in the future in order to be able to assess the suitability of the model. It will be helpful in the next step to include grey literature in the analysis as well in order to gain even more approaches and scientific legitimacy for the developed model. In the future, more models will be developed, which should also be included in the evaluation. A constant adaptation of the requirements will also be necessary, as they may change due to the disruptive and ever-changing nature of the subject. The last point to mention is that the process model follows a multi-method approach, for which additional tools still need to be developed for the quantitative assessment of blockchain projects and their impact.

References

1. Connelly, B.L., Ketchen, D.J. and Hult, G.T.M.(2013), “Global supply chain management: towards theoretically driven research agenda”, *Global Strategy Journal*, Vol.3 No.3,pp.227-243.
2. Chen, S., Shi, R., Ren, Z., Yan, J., Shi, Y., & Zhang, J. (2017, November). A blockchain-based supply chain quality management framework. In 2017 IEEE 14th International Conference on e-Business Engineering (ICEBE) (pp. 172-176). IEEE.
3. Treiblmaier, H.(2018), “The impact of the blockchain on the supply chain: a theory-based research framework and a call for action”, *Supply Chain Management: An International Journal*, Vol.23 No. 6,pp.545-559.
4. Wang, H.; Zheng, Z.; Xie, S.; Dai, H. N.; Chen, X. (2018): Blockchain challenges and opportunities: a survey. In: *International Journal of Web and Grid Services (IJWGS)*, 14 (4), S. 352.
5. Rawat, D. B.; Chaudhary, V.; Doku, R. (2019): Blockchain: Emerging applications and use cases. In: arXiv preprint arXiv:1904.12247.
6. Wittenberg, Stefan. *Blockchain für Unternehmen: Anwendungsfälle und Geschäftsmodelle für die Praxis*. Schäffer-Poeschel, 2020.
7. Gentemann, L. (2019): *Blockchain in Deutschland–Einsatz, Potenziale, Herausforderungen*. In: Bitkom e. V., Berlin.
8. CSCMP (2013): *Supply Chain Management. Terms and Glossary*. Online verfügbar unter https://cscmp.org/CSCMP/Educate/SCM_Definitions_and_Glossary_of_Terms/CSCMP/Educate/SCM_Definitions_and_Glossary_of_Terms.aspx, zuletzt geprüft am 28.04.2022.
9. Muchna, C.; Brandenburg, H.; Fottner, J.; Gutermuth, J. (2018): *Grundlagen der Logistik. Begriffe, Strukturen und Prozesse*. Wiesbaden: Springer Gabler.

10. Cooper, M. C., Lambert, D. M., & Pagh, J. D. (1997). Supply chain management: more than a new name for logistics. *The international journal of logistics management*, 8(1), 1-14.
11. Liebetruth, T. (2016). *Prozessmanagement in Einkauf und Logistik*. Springer Fachmedien Wiesbaden.
12. Stevens, G. C. (1989). Integrating the supply chain. *international Journal of physical distribution & Materials Management.*, Vol. 19, no. 8, pp. 3-8. 1989
13. Salcedo, S., & Grackin, A. (2000). The e-value chain. *Supply Chain Management Review*, 3(4), 63-70.
14. Guggenberger, T., Schweizer, A., & Urbach, N. (2020). Improving interorganizational information sharing for vendor managed inventory: Toward a decentralized information hub using blockchain technology. *IEEE Transactions on Engineering Management*, 67(4), 1074-1085.
15. Abeyratne, S. A., & Monfared, R. P. (2016). Blockchain ready manufacturing supply chain using distributed ledger. *International Journal of Research in Engineering and Technology*, 5(9), 1-10.
16. Chuen, D. L. K. (Ed.). (2015). *Handbook of digital currency: Bitcoin, innovation, financial instruments, and big data*. Academic Press.
17. Swan, M. (2015): *Blockchain: Blueprint for a new economy*. Sebastopol: O'Reilly & Associates.
18. Hackius, N., & Petersen, M. (2017). Blockchain in logistics and supply chain: trick or treat?. In *Digitalization in Supply Chain Management and Logistics: Smart and Digital Solutions for an Industry 4.0 Environment*. Proceedings of the Hamburg International Conference of Logistics (HICL), Vol. 23 (pp. 3-18). Berlin: epubli GmbH.
19. Henke, M.; Schulte, A. T.; Jakob, S. (2020b): Blockchain-basiertes Supply Chain Management. In: Hompel, M. ten; Bauernhansl, T.; Vogel-Heuser, B. (Hrsg.): *Handbuch Industrie 4.0. Band 3: Logistik*. Berlin: Springer; Springer Berlin Heidelberg; Imprint: Springer Vieweg, S. 599–615.
20. Verhoeven, P., Sinn, F., & Herden, T. T. (2018). Examples from blockchain implementations in logistics and supply chain management: exploring the mindful use of a new technology. *Logistics*, 2(3), 20.
21. Wang, Y., Han, J. H., & Beynon-Davies, P. (2018). Understanding blockchain technology for future supply chains: a systematic literature review and research agenda. *Supply Chain Management: An International Journal*.
22. Webster, J., & Watson, R. T. (2002). Analyzing the past to prepare for the future: Writing a literature review. *MIS quarterly*, xiii-xxiii.
23. Guerpinar, Tan, et al. "Blockchain technology: Integration in supply chain processes." *Data Science and Innovation in Supply Chain Management: How Data Transforms the Value Chain*. Proceedings of the Hamburg International Conference of Logistics (HICL), Vol. 29. Berlin: epubli GmbH, 2020.
24. Arun, Jai Singh, Jerry Cuomo, and Nitin Gaur. *Blockchain for business*. Addison-Wesley Professional, 2019.
25. Attaran, Mohsen, and Angappa Gunasekaran. *Applications of blockchain technology in business: challenges and opportunities*. Springer Nature, 2019.
26. Fill, Hans-Georg, and Andreas Meier. *Blockchain*. Springer Fachmedien Wiesbaden, Wiesbaden, 2020.

27. Urban, Nicklas T. "Blockchain for Business." Springer Books (2020).
28. Vu, Nam, Abhijeet Ghadge, and Michael Bourlakis. "Blockchain adoption in food supply chains: a review and implementation framework." *Production Planning & Control* (2021): 1-18.
29. Dujak, D., & Sajter, D. (2019). Blockchain applications in supply chain. In *SMART supply network* (pp. 21-46). Springer, Cham.
30. Queiroz, M. M., Telles, R., & Bonilla, S. H. (2019). Blockchain and supply chain management integration: a systematic review of the literature. *Supply Chain Management: An International Journal*.
31. Dispan, J., & Schwarz-Kocher, M. (2018). Digitalisierung im Maschinenbau. Entwicklungstrends, Herausforderungen, Beschäftigungswirkungen, Gestaltungsfelder im Maschinen-und Anlagenbau (No. 94). Working Paper Forschungsförderung.
32. Mendling, J., Weber, I., Aalst, W. V. D., Brocke, J. V., Cabanillas, C., Daniel, F., ... & Zhu, L. (2018). Blockchains for business process management-challenges and opportunities. *ACM Transactions on Management Information Systems (TMIS)*, 9(1), 1-16.
33. Sternberg, H. S., Hofmann, E., & Roeck, D. (2021). The struggle is real: insights from a supply chain blockchain case. *Journal of Business Logistics*, 42(1), 71-87.
34. Morabito, V. (2017). *Business innovation through blockchain*. Cham: Springer International Publishing.
35. Saberi, S., Kouhizadeh, M., Sarkis, J., & Shen, L. (2019). Blockchain technology and its relationships to sustainable supply chain management. *International Journal of Production Research*, 57(7), 2117-2135.
36. Kshetri, N. (2018). 1 Blockchain's roles in meeting key supply chain management objectives. *International Journal of Information Management*, 39, 80-89.
37. Weking, J., Mandalenakis, M., Hein, A., Hermes, S., Böhm, M., & Krcmar, H. (2020). The impact of blockchain technology on business models—a taxonomy and archetypal patterns. *Electronic Markets*, 30(2), 285-305.
38. Chong, A. Y. L., Lim, E. T., Hua, X., Zheng, S., & Tan, C. W. (2019). Business on chain: A comparative case study of five blockchain-inspired business models. *Journal of the Association for Information Systems*, 20(9), 9.
39. Highsmith, J. (2009). *Agile project management: creating innovative products*. Pearson education.
40. Saghiri, A. M. (2020). Blockchain architecture. In *Advanced applications of blockchain technology* (pp. 161-176). Springer, Singapore.
41. Osterland, T., & Rose, T. (2020). From a use case categorization scheme towards a maturity model for engineering distributed ledgers. In *Blockchain and Distributed Ledger Technology Use Cases* (pp. 33-50). Springer, Cham.
42. Iansiti, M., Lakhani, K.R., 2017. The truth about blockchain. *Harvard Business Review* 95(1), 118-127.
43. Dutta, P., Choi, T. M., Somani, S., & Butala, R. (2020). Blockchain technology in supply chain operations: Applications, challenges and research opportunities. *Transportation research part e: Logistics and transportation review*, 142, 102067.

44. Qu, Y., Ming, X., Ni, Y., Li, X., Liu, Z., Zhang, X., & Xie, L. (2019). An integrated framework of enterprise information systems in smart manufacturing system via business process reengineering. *Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture*, 233(11), 2210-2224.
45. Platt, M., Sedlmeir, J., Platt, D., Tasca, P., Xu, J., Vadgama, N., & Ibañez, J. I. (2021). Energy footprint of blockchain consensus mechanisms beyond proof-of-work. *arXiv preprint arXiv:2109.03667*.
46. Perboli, G., Musso, S., & Rosano, M. (2018). Blockchain in logistics and supply chain: A lean approach for designing real-world use cases. *Ieee Access*, 6, 62018-62028.
47. Chen, I. J., & Paulraj, A. (2004). Understanding supply chain management: critical research and a theoretical framework. *International Journal of production research*, 42(1), 131-163.