Niels Hackius

Blockchain Adoption in Supply Chain Management and Logistics

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1. Gutachter: Prof. Dr. Dr. h. c. Wolfgang Kersten
Institut für Logistik und Unternehmensführung
Technische Universität Hamburg
2. Gutachter: Prof. Dr. Moritz Petersen
Kühne Logistics University

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for the love, friendship, freedom, inspiration, kairos, the fish, and everything.

Sophia Kronawitter • Sven Reimers • Irene Zamora • Moritz Göldner

Antje & Ulf Hackius

Sally Lind • Lino Stephani • Susanne Vogel • Maik Gröger • Bente Rathmann
Sofa-Café • Franziska Bomba • Paul Craig • Aida & Maren Wichmann
Birgit von See • Moritz Petersen • UoT
Christoph Loose • Alexandra Elbakyan • Tobias Reaper
Lorne Lantz • Loituma Girl •Vladislav Balovatsky • Lea-Marie Becker
Julia Craig • Tobias Kronawitter

Summary

The tight integration of materials flow with the flow of information remains a challenge in supply chain and logistics (SC&L). Blockchain is an emerging technology concept that could be a tool to solve end-to-end information flow. It provides a distributed, decentralized ledger of transaction records that are tamper-resistant due to cryptographic methods. Transaction data in SC&L could be a history of state changes, ownerships, or manufacturing steps.

This dissertation addresses the adoption of Blockchain solutions in the SC&L context in three complementary studies. In Study 1, the existing literature is analyzed. A sample of 135 articles is mapped to the use cases and the industries they address. In Study 2, practitioners' anticipations of Blockchain are surveyed. An online questionnaire yielded 153 responses regarding four use cases as well as barriers and beneficiaries. Finally, in the main study – Study 3 – qualitative data were collected to investigate how companies are adopting Blockchain using an exploratory Grounded Theory approach.

The literature review in Study 1 showed that, overall, there has been little empirical work to date. However, the sample yielded eight major use cases that predominantly address the food and the pharmaceutical industries. Study 2 illustrated that while practitioners expect Blockchain solutions to take hold throughout the industry, regulatory uncertainties regarding the technology's uses and legal validity as well as the need for collaboration with new partners along the supply chain remain barriers. Study 3 allowed for the creation of a typology of companies' motivations for starting to work with Blockchain solutions and a model of which adoption paths they choose, the learnings they derive, and the barriers they face.

The conclusion that Blockchain will shape SC&L in the future emphasizes the need to further explore this space. On the one hand, more empirical data should be collected to describe tailor-made concepts that also fit such ecosystems. On the other hand, this also requires solutions for the existing barriers and general strategies for supply chain-wide Blockchain solution deployment. In the long run, Blockchain solutions could develop into a very valuable, massive infrastructure tool that allows one to drive efficiency by aligning supply chain partners worldwide. Further, it could allow for multi-supply chain ecosystems as a basis to offer a range of value-added services, for instance, providing identities, certification, or anti-counterfeiting solutions.

Table of Contents

List of Tables XI

List of Figures XIII

List of Abbreviations XV

1 Introduction 1
- 1.1 Research Objective and Research Questions . . . 3
- 1.2 Research Structure . . . 4

2 Theoretical Background 7
- 2.1 Supply Chain Management and Logistics . . . 7
  - 2.1.1 Supply Chain Management . . . 8
  - 2.1.2 Logistics . . . 11
- 2.2 Blockchain Technology . . . 14
  - 2.2.1 Technological Concept . . . 14
  - 2.2.2 Blockchain Implementations, Applications, and Solutions 16

3 Mapping the Literature on Blockchain in Supply Chain Management and Logistics 21
- 3.1 Method . . . 22
- 3.2 Results . . . 26
  - 3.2.1 Overview over the Sample . . . 26
  - 3.2.2 Analysis of the Use Cases . . . 28
  - 3.2.3 Analysis of the Research Approaches . . . 47
- 3.3 Discussion . . . 53
- 3.4 Preliminary Conclusions . . . 56
  - 3.4.1 Implications for Research . . . 56
  - 3.4.2 Implications for Management . . . 56
  - 3.4.3 Limitations and Opportunities for Further Research . . . 59

4 Surveying Anticipations of Blockchain in Supply Chain Management and Logistics Practice 61
4.1 Method . . . 62
4.1.1 Use Case Examples . . . 62
4.1.2 Setup and Data Collection . . . 66
4.2 Results . . . 67
4.3 Discussion . . . 72
4.4 Preliminary Conclusions . . . 73
4.4.1 Implications for Research . . . 74
4.4.2 Implications for Management . . . 74
4.4.3 Limitations and Opportunities for Further Research . . . 76

5 Exploring Blockchain Adoption in Supply Chain Management and Logistics Practice 79
5.1 Method . . . 80
5.2 Results and Discussion . . . 84
5.2.1 Motivation: A Company Typology . . . 86
5.2.2 The Organizational Adoption Path . . . 98
5.2.3 Practical Adoption Path . . . 105
5.2.4 External Barriers . . . 111
5.2.5 Internal Barriers . . . 121
5.2.6 Learnings . . . 128
5.3 Preliminary Conclusions . . . 142
5.3.1 Implications for Research . . . 142
5.3.2 Implications for Management . . . 144
5.3.3 Limitations and Opportunities for Further Research . . . 147

6 Conclusion and Outlook 153

Bibliography 163

Appendix A Scales 189

Appendix B Questionnaire 191

Appendix C Interview Guideline 196

Appendix D Interview Sample 198

List of Tables

2.1 Configurations of Blockchain Access Permissions 18

3.1 Steps in the Systematic Literature Review Approach 23
3.2 Databases Used for the Literature Research 24
3.3 Excluded Articles 25
3.4 Included Articles by Year 27
3.5 Articles Identified for the Tracing Goods Use Case 30
3.6 Articles Identified for the Documenting Goods and Process Steps Use Case 33
3.7 Articles Identified for the Preventing Counterfeiting Use Case . . 35
3.8 Articles Identified for the Transparency Use Case 37
3.9 Articles Identified for the Decentralizing Access to Information Use Case 39
3.10 Articles Identified for Improving the Analysis and Measurement of Performance Use Case 40
3.11 Articles Identified for the Improving Communication Security Use Case 42
3.12 Articles Identified for the Providing Infrastructure for IoT Devices Use Case 43
3.13 Articles Identified for the Other Use Cases 45
3.14 Articles in the Sample Using an Empirical Research Approach . . 49
3.15 Embedding the Implications (1-4) for Management in a Process Model 57

4.1 Descriptions of the Use Cases as Shown in the Web-Based Survey 63
4.2 Benefits of Blockchain 69
4.3 Likelihood of Adopting Blockchain 69
4.4 Embedding the Implications (1-7) for Management in a Process Model 75

5.1 Typology of Ideal Company Types 87
5.2 Embedding the Implications (1-12) for Management in a Process Model 145
5.3 Overview over the Observations 149

A.1 Scales Used for the Questionnaire 189

B.1 Questionnaire Used for the Web-Based Survey 191

C.1 Interview Guideline 197

D.1 Sample of the Expert Interview Study 199

List of Figures

1.1 Structure of This Thesis 5

2.1 Supply Chain Management Framework from the Perspective of a Focal Company 9
2.2 Overview over the Logistics Sectors in the EU30 12
2.3 Basic Blockchain Properties 14
2.4 Overview of a Blockchain solution 16

3.1 Distribution of Authors of Articles in the Sample 27
3.2 Overview of Industries and Use Cases 29
3.3 Overview of Research Approaches and Industries 51
3.4 Overview of Research Approaches and Use Cases 52

4.1 Participants and their Companies 67
4.2 Companies' Stances toward Blockchain 68
4.3 Beneficiaries of Blockchain 71
4.4 Barriers to Blockchain Adoption 71

5.1 Research Process of Constructing Grounded Theory 81
5.2 Blockchain Adoption in SC&L: Company Types, Paths, Barriers, Learnings and Their Relationships 85

List of Abbreviations

API application programming interface

B/L bill of lading

CEP courier express parcel

CRM customer relationship management software

CSCMP Council of Supply Chain Management Professionals

DAO decentralized autonomous organization

DLT distributed ledger technology

EDI electronic data interchange

ERP enterprise resource planning

EU 30 European Union member states, Norway, Switzerland, and the UK

FTL full truckload

GDPR General Data Protection Regulation

HACCP hazard analysis and critical control points

IoT Internet of things

IP intellectual property

ISO international organization for standardization

LTL less-than-truckload

NFC near-field communication

NGO non-governmental organization

PAT principal-agent theory

PLS partial least squares structural equation modeling

PoC proof of concept

RBV resource-based view

RFID radio-frequency identification

SC&L supply chain management and logistics

SME small and medium-sized enterprises

TAM technology acceptance model

UK United Kingdom

WMS warehouse management system

Chapter 1

Introduction

"On the Internet, nobody knows you are a dog," Steiner's 1993 cartoon reads. Entirely feasible at the time, in 2020 it requires enormous effort for people to remain anonymous online, with no guarantee of success (Marx et al. 2018; Lufkin 2017; Snowden 2019, pp. 248–252). It could be expected that the same applies to the origins and locations of goods and materials, since information–sharing is considered crucial for supply chain management and logistics (SC&L) (Cooper et al. 1997). Nonetheless, for most supply chains, the tight integration of the material flow with the information flow remains wishful thinking (Kersten et al. 2017; Huong Tran et al. 2016). For instance, it's almost impossible to track the journey of an avocado's journey from the supermarket shelf back to the tree that gave it life (Park 2018; Popper et al. 2017).

Effective information-sharing, for instance about the demand changes and the inventory levels of different supply chain tiers, would improve the entire supply chain's competitiveness (Christopher 2016). It also allows for swift reactions to disruptions that cascade across tiers and the entire supply network (Donadoni et al. 2019). For instance, the Great East Japan Earthquake in March 2011, which ultimately resulted in the meltdown of the Fukushima nuclear power plant, severely disrupted supply chains in different industries (Hendricks et al. 2020). Unexpected demand changes, such as the spike in thermometer sales during the COVID-19 pandemic (Corkery et al. 2020) or more local natural disasters, necessitate immediate overviews over inventory levels, production volumes, and goods in transit if one is to decide on countermeasures. However, optimally organizing the information flow is crucial beyond disruptions. It can benefit supply chain performance and is also a key enabler of future concepts such as closed-loop supply chains in a circular economy (Shekarian 2020).

Electronic data interchange (EDI) – a data standard designed in the 1960s and already split into more than 10 sets (e.g., the UN/EDIFACT or the GS1 EDI standard) is far from widely used within SC&L (Huong Tran et al. 2016; Hermes Germany GmbH 2017; Ferrantino et al. 2017). Further, even EDI use does not mean the full integration of the flows of information and material. It is more common in practice to use less integrated methods (e.g., telephone and e-mail communication) instead of fully integrated solutions (Hermes Germany GmbH 2017; Huong Tran et al. 2016; Kersten et al. 2017). One consequence is the creation of different versions of the same records in various places: Copies of the relevant information are exchanged through specialized platform providers, or directly from one company to another via physical documents or electronic interfaces (Jabbar et al. 2018; Madenas et al. 2014). For instance, the documentation of freight transports from East Asia to Europe involves around 30 actors, causing 15% of total shipment costs (Groenfeldt 2017; Jabbar et al. 2018).

Blockchain could change this; it is a technology concept that provides a distributed, decentralized ledger of transaction records that is tamper-resistant due to the use of cryptographic methods (The Economist 2015; Popper et al. 2017; Nakamoto 2008; Tapscott et al. 2016; Pilkington 2016). Transaction data in SC&L could be a history of state changes (e.g., locations or temperatures) and ownerships (e.g., shipment handlers, parts manufacturers, or raw material producers). The central promise of Blockchain is that it creates a single and shared data repository, allowing all network members to read or write to its ledger. Its decentralization makes it especially useful in multistakeholder environments with short-lived business relationships (Wüst et al. 2018; Wang et al. 2018; Petersen et al. 2018).

Thus, Blockchain could be the long-sought-after tool that will solve end-to-end information flow for SC&L. First practical concepts include record keeping for the production of jewelry diamonds, shadowing documentation of international container transports, handling and production records of leafy green vegetables and salads, and the identification of truck drivers for container release at the port of Antwerp (Stahlbock et al. 2018; Corkery et al. 2018; Groenfeldt 2017; Yarm 2019).

1.1 Research Objective and Research Questions

The outlined practical examples illustrate Blockchain's broad spectrum of possible applications in SC&L. However, Blockchain is still a relatively new technology that is not yet widely deployed. Besides, to date, there are only a few practical concepts and even fewer documented learnings in the SC&L context. Thus, there have been few insights into practitioners' understandings of deploying Blockchain in SC&L is limited; there is almost no documentation on the factors that companies consider when adopting Blockchain in SC&L. Despite this lack of understanding, Blockchain's impacts on SC&L could potentially be extensive. This thesis pursues the following research objective:

> **RO:** To gain a better understanding of the Blockchain adoption process and its implications for supply chain management and logistics.

This objective stems directly from the observation that Blockchain technology is slowly diffusing into areas beyond cryptocurrencies and the idea therein that each good could have an end-to-end record of every production and handling step.

The research questions address this directly. The first question aims to map the state of the literature. The intention is to outline which use cases have been conceptualized as well as the data gathered therein. The following question is investigated in Chapter 3 on page 21:

> **RQ1:** How has Blockchain adoption in SC&L been discussed in the literature?

Besides the perspective presented in the literature, the practitioners' expectations should be investigated, including the extent to which they consider Blockchain applications beneficial and the impacts they think it will have on SC&L. In Chapter 4 on page 61, the following question is investigated:

> **RQ2:** How have practitioners perceived Blockchain's benefits and prospects in SC&L?

The results of questions 1 and 2 also motivate question 3: If there are possible concepts and practitioners show an interest in using Blockchain solutions, the considerations on the path to Blockchain adoption in SC&L should be investigated. Question 3, investigated in Chapter 5 on page 79, is:

> **RQ3:** How have companies been adopting Blockchain in SC&L?

Each research question calls for different research methods introduced in every chapter to answer each question.

1.2 Research Structure

The thesis is structured along the research questions, which are each addressed separately in chapters 3 to 5 (see Figure 1.1 on the next page). Chapter 2 on page 7 introduces concepts and terminology regarding supply chain management, logistics, and Blockchain. In Chapter 3 on page 21, the SC&L literature is reviewed in order to answer research question 1. In Chapter 4 on page 61, practitioners' opinions are captured by an online survey to answer research question 2. After gaining an insights into the SC&L literature and taking practitioners' evaluations into account, approaches to adoption are discussed in Chapter 5 on page 79 which presents the results of an explorative qualitative Grounded Theory study, investigating how Blockchain could be adopted in SC&L practice. Chapter 6 on page 153 addresses the achievement of the research objective and provides an overall summary to conclude the thesis.

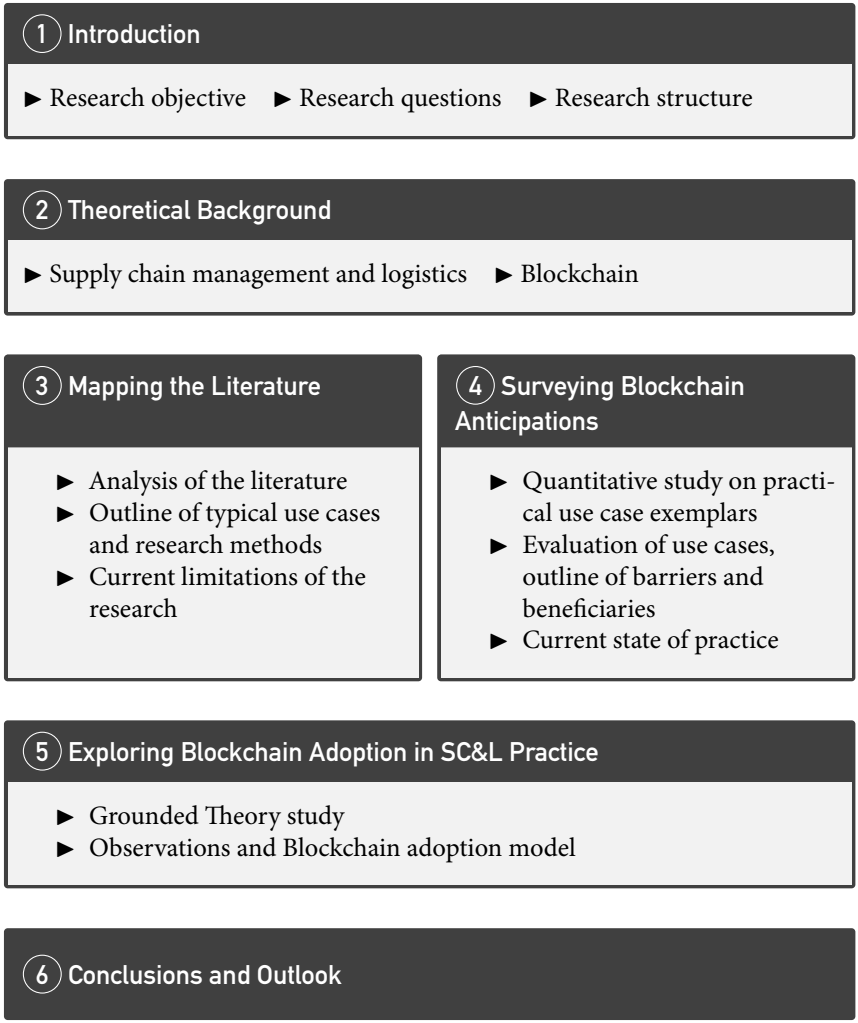


Figure 1.1: Structure of This Thesis

Chapter 2

Theoretical Background

This chapter outlines the terminology used regarding supply chain management and logistics (SC&L) and briefly introduces Blockchain technology and its key terms.

2.1 Supply Chain Management and Logistics

Supply chains are the continual flow of information, materials, and finances, among other processes necessary for fulfilling customer requests. Managing these supply chains almost always involves the movement of physical goods using logistics services. This tight connection between supply chain management and logistics has led to the terms being used interchangeably.

Depending on the author, these terms have different scopes, ranging from interchangeable use to merely overlapping in parts. Larson et al. (2007) identified four conceptual positions that cover all cases. These include *traditionalists*, who see "supply chain management as a function or subset of logistics" (Larson et al. 2007, p. 4), *relablers*, who imply "what was logistics is now supply chain management" (Larson et al. 2007, p. 4), and the *intersectionists*, who see the strategic parts of logistics decisions as part of supply chain management. The *unionist* perspective considers "logistics as a function of supply chain management" (Larson et al. 2007, p. 4). In this perspective, the logistics functionalities, transport, storage, and distribution – the material flow of goods and materials – are considered a distinct and separate subfunctionality within supply chain management.

In this thesis, this unionist perspective is assumed, because in practice logistics remains crucial for a functioning supply chain yet is often discussed separately. The abbreviation SC&L reflects the inclusion of both "supply chain management and logistics". Supply chain management and logistics are defined separately in the following sections.

2.1.1 Supply Chain Management

A supply chain is defined as consisting "of all parties involved, directly or indirectly, in fulfilling a customer request." (Chopra et al. 2016, p. 13). Notably, customer needs drive this material flow that links a network of companies through a stream of materials, goods, and products (Council of Supply Chain Management Professionals 2013, p. 186; Chopra et al. 2016, pp. 13–16).

A simple supply chain may look like this (compare Chopra et al. 2016, pp. 13–16): A parent opens the website of the online retailer Amazon looking for a stuffed toy triceratops dinosaur for their child. Amazon provides an online store and sends the toy to the parent using a courier express parcel (CEP) delivery company. Before it can do this, it must stock the toys that are supplied by the manufacturer (e.g., Steiff) and delivered to Amazon in bulk by a trucking company. Steiff receives its materials (e.g., polyester, fabric, or colors) from different raw material suppliers. Further, both Amazon and Steiff need packaging material as well as administrative services and supplies that they will have to buy from yet another supplier.

This brief example illustrates that supply chains are more complex than merely converting raw materials into a product (Chopra et al. 2016, p. 14; Bowersox et al. 2020, pp. 5–6). In practice, typically, more than one raw material from more than one company is needed, involving multiple suppliers. Likewise, manufacturing requires a network of machines or factories that make intermediary products, parts, or product modules, leading a final product. The sale of this final product is just as complex, because many retail channels, different customer types, and markets exist. Transportation between all these players require logistics operations in an extensive network using different, adequate transportation modes and warehousing.

Supply chain management means to manage the complex network that is a supply chain (Lambert 2014, p. 4). However, supply chain management is more than managing the material flow and the required logistics services (Christopher 2016, pp. 2–3; Min et al. 2019; Bowersox et al. 2020, pp. 3–4). On the one hand, a

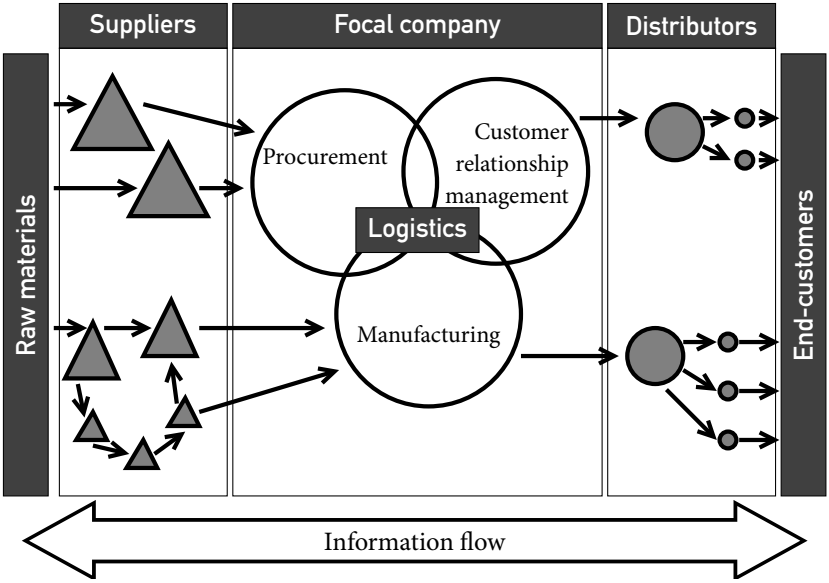


Figure 2.1: Supply Chain Management Framework from the Perspective of a Focal Company (the arrows that connect the shapes represent the material flow) (based on Bowersox et al. (2020, p. 6))

company's operational logistics tasks must be augmented by tactical planning and controlling activities (Bowersox et al. 2020, pp. 36–39). On the other hand, supply chain management has a strategic role in companies (Min et al. 2019). Its purpose is to create value for the customers by seamlessly integrating the flow of materials with the other corresponding activities, such as forecasting, order management, and product research (Min et al. 2019; Christopher 2016, pp. 4–14; Lambert 2014, pp. 2–5). Managing supply networks means reaching out beyond company borders for collaboration and business relationships (Christopher 2016, pp. 10–11; Min et al. 2019; Bowersox et al. 2020, pp. 6–7). Figure 2.1 shows this network in the example of a focal enterprise. All the suppliers and distributors are connected to the focal enterprise functions through logistics services as the channel to manage the product flow (Bowersox et al. 2020, p. 6).

As outlined, SC&L unifies many management processes and process flows under its roof (Lambert 2014, p. 3); however, the material flow and the information flow stand out because the other processes (e.g., service or financial flows) depend on these (Bowersox et al. 2020, p. 6; Lambert 2014, p. 3). The previous section introduced the material flow, which involves supplying raw materials to the manufacturer, which turns the materials into a product, which is then sold to a customer by a retailer (Bowersox et al. 2020, p. 6; Lambert 2014, p. 3). This material flow requires the flow of information to correspond to its interactions in the network of suppliers and distributors.

The information flow involves everything from short-term shipment status communication to long-term pricing communications. The material flow, SC&L optimization processes, and all other supply chain management functions require the information flow to function correctly (Christopher 2016, pp. 11–12., 211; Lambert 2014, pp. 3–5). Propagating information upstream allows for more precise demand planning, just as it helps downstream to anticipate changes or delays. The need to share information has long been articulated in the literature and has been identified to cause, for instance, the bullwhip effect (Fawcett et al. 2002; Lee et al. 1997). However, sharing more information can be advantageous because the more integrated the information flow is, the more competitive the whole supply chain becomes (Fawcett et al. 2016).

Thus, optimizing the information flow is an attractive opportunity for SC&L and is expected to be highly disruptive (von See 2019, p. 164; Kersten et al. 2018; Hartley et al. 2019; Büyüközkan et al. 2018). Hartley et al. (2019) and Lyall et al. (2018) note that the role of supply chain management as a business function is undergoing considerable changes owing to the use of more digital tools. However, these tools and overarching concepts of information-sharing across the supply chain network are only diffusing slowly (Lyall et al. 2018; Kersten et al. 2017; Büyüközkan et al. 2018).

2.1.2 Logistics

Logistics services completely take care of all material flows of raw materials, goods, and products inside and between companies from the source to the end-customer. Pfohl (2018, pp. 10–11) and Bowersox et al. (2020, p. 36) described logistics as the business operation involving the order processing, transportation, and anything related to warehousing (e.g., material handling, packaging, and inventory). The Council of Supply Chain Management Professionals (CSCMP) Glossary defined logistics as "The process of planning, implementing, and controlling procedures for the efficient and effective transportation and storage of goods including services, and related information from the point of origin to the point of consumption for the purpose of conforming to customer requirements. This definition includes inbound, outbound, internal, and external movements." (Council of Supply Chain Management Professionals 2013, p. 117). A third way to describe logistics are the *four rights of logistics*: "to deliver the right product, in the right condition, at the right time, to the right place at minimal cost" (Pfohl 2018, p. 12), often extended by including the right quantity of the product and the correct customer.

In this function, the logistics sector is an integral part of the global economy and has grown continually in the last 10 years (A. T. Kearney 2020, pp. 17, 68; Bundesvereinigung Logistik e. V. et al. 2019). In 2018, with a turnover of over €1 trillion, the logistics sector represented 7% of the GDP of the European Union member states, Norway, Switzerland, and the UK (EU 30) (Schwemmer 2019, p. 35). In the EU 30, logistics services employ more than 13 million people, more than three million of these in Germany (Schwemmer 2019, p. 53).

Especially the steep rise in online sales has boosted the growth of the logistics services sector unitl the end of 2018 (Schwemmer 2019, p. 33; A. T. Kearney 2020, p. 7). However, the direct end-customer sales also puts competitive pricing pressure on the sector (A. T. Kearney 2020, p. 7; Kersten et al. 2017, p. 34). Logistics costs mainly amount to transportation (46% of ≈ €1 120B) and warehousing (32% of ≈ €1 120B) (Schwemmer 2019, p. 41).

In 2018, more than 18 billion tons of materials and goods were moved by EU 30 logistics services. The vast majority of this transport volume was handled through road transport (≈ 77% /14.6B tons in 2018) (Schwemmer 2019, pp. 34–35). However, the other key transportation modes with less overall volume include ocean (≈ 9%/1.7B tons in 2018), railway (≈ 6%/1.2B tons in 2018), inland water transport (≈ 3%/0.5B tons in 2018), and, at much lower volume, air transport (≈0.05%/0.1B tons

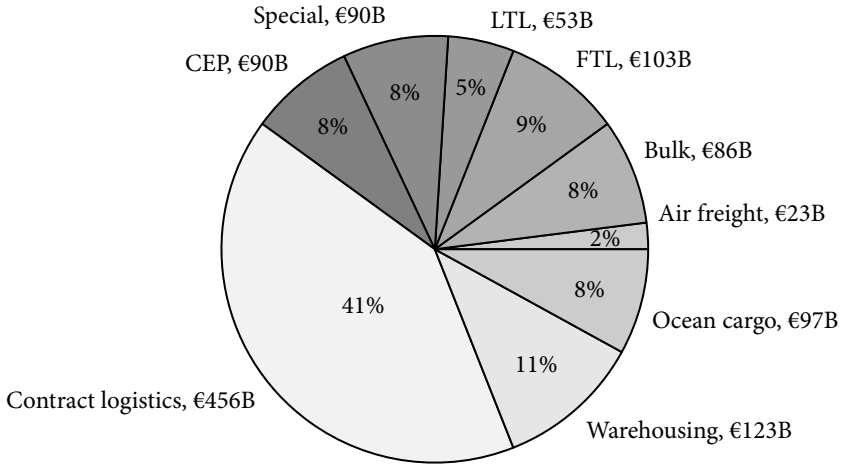


Figure 2.2: Overview over the Logistics Sectors in the EU 30 by Logistics Segments (in billion € and % of a €1 120B total) (data from 2018 according to Schwemmer (2019))

in 2018) (Schwemmer 2019, pp. 34–35). Pipeline transport made up 4.4% (0.9B t) of the total transport volume in 2018, which helps to understand that logistics is more than transporting goods from manufacturers to end-customers (Schwemmer 2019, pp. 34–35).

Various logistics companies from different service segments carry out the fulfillment of these services. Figure 2.2 provides an overview: Contract logistics providers, also called integrated logistics providers (ISPs), third-party (3PL), or fourth-party logistics (4PL)[1] providers, allow companies to outsource their logistics tasks (Schwemmer 2019, pp. 55–57; Bowersox et al. 2020, pp. 11–13). These companies take care of all logistics tasks by organizing warehousing and transport, typically utilizing IT services and sometimes even providing consulting services for their customers' (Schwemmer 2019, pp. 55–57; Bowersox et al. 2020, pp. 11–13). Ocean and air freight refer to the carriers that specialize in these transport modes. Bulk logistics refers to the moving of bulky materials such as coal, sand, grains, or chemicals

1 The difference between 3PL and 4PL providers typically is that 3PL also has own assets it uses while 4PL is a fully virtual company.

(Schwemmer 2019, p. 55; Bowersox et al. 2020, p. 7). These are typically moved by rail, inland barge, or truck fleets that specialize in moving high volumes of these liquids or raw materials (Schwemmer 2019, p. 55; Bowersox et al. 2020, p. 7). Full truckload (FTL) and less-than-truckload (LTL) refer to road transports in semi-trailers or shipping containers. Unlike FTL, LTL service providers combine multiple parties' freight, often not delivering the freight directly, but collecting and distributing them locally through terminals and cross-docks (Schwemmer 2019, p. 55). FTL and LTL providers typically use standardized semi-trailers or trucks. In contrast, specialized transport logistics providers provide services or machinery with a focus on specific products or markets, for instance, special trucks for perishables, livestock, or waste, or special handling for museums, textiles, or large machine parts, such as wind turbines (Orf 2014; Bowersox et al. 2020, p. 193; Schwemmer 2019, p. 55). Courier express parcel (CEP) refers to logistics services that deliver parcels (typically up to 31.5 kg) or documents door-to-door (Schwemmer 2019, p. 56; Bowersox et al. 2020, pp. 197–200). Warehousing services are independently operated storage and handling facilities. The numbers in Figure 2.2 on the preceding page show their turnover beyond contract logistics.

Depending on the segment, all these companies have a different market reach and specialize in different customers. For instance, CEP logistics operators such as DHL or UPS operate worldwide. They can quickly deliver parcels and documents door-to-door, yet there are bike messengers who address customers who need even quicker, more local courier services (Maes et al. 2012). Accordingly, in practice, it is usually necessary for different logistics service providers to work together to achieve end-to-end materials and product flow. During these logistics services, the supply chain management processes running in parallel must be addressed. In particular, it is crucial that the information flow be managed, because missing information can lead to interruptions. The ways logistics service providers provide information depend on their task and service segment. Large contract logistics providers often have more tightly integrated systems that integrate with strategic partners and provide customer interfaces, while smaller companies serve these manually (Huong Tran et al. 2016; Hermes Germany GmbH 2017).

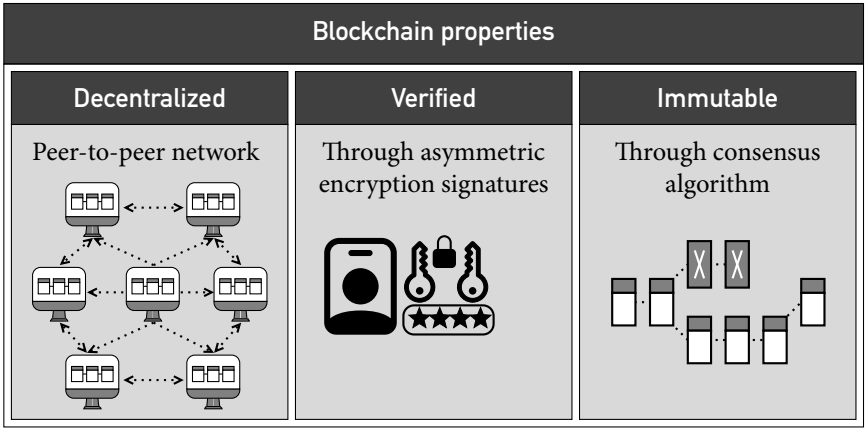


Figure 2.3: Basic Blockchain Properties (see also Hackius et al. 2017)

2.2 Blockchain Technology

Blockchain is often used interchangeably and depending on the context. The meanings range from references to the technological concept generally to software implementations such as Bitcoin or Ethereum or user-facing applications. To prevent confusion, the underlying technological concept of a Blockchain and the differences between the terms Blockchain solutions, Blockchain applications, and Blockchain implementations will now be outlined.

2.2.1 Technological Concept

Blockchain is a software technology concept that provides a distributed, decentralized ledger of transaction records that are tamper-resistant due to the use of cryptographic methods (Nakamoto 2008; Buterin 2013; The Economist 2015; Pilkington 2016). Figure 2.3 illustrates the technology concept of a Blockchain and its three basic properties. Authors occasionally prefer to use the superordinate term distributed ledger technology (DLT) when referring to Blockchain technology concepts (Roeck et al. 2020). A distributed ledger is not necessarily a Blockchain, because it does not necessarily provide immutability or a consensus algorithm.

In a Blockchain concept, decentralization utilizes a peer-to-peer network run by its members (Nakamoto 2008; Buterin 2013; Pilkington 2016). Thus, the members do not rely on a central operator or a centralized infrastructure; each member can add transactions to the ledger by sharing it within a Blockchain peer-to-peer network; and all the participants work with the same state of transaction data, preventing disjunctive, local versions of data.

Transactions are verified, because the network members must sign their transactions using asymmetrical cryptography before sharing them with the network (Nakamoto 2008; Buterin 2013; Pilkington 2016). Only the owner of a specific private key owner can initiate transactions belonging to the corresponding public key. The keys are not necessarily directly linked to real-world identities; however, a shorter representation of the public key serves as a pseudonym in many Blockchain implementations.

The immutability of the Blockchain is achieved by using a consensus algorithm that groups one or more transactions into so-called *blocks* (Nakamoto 2008; Buterin 2013; Pilkington 2016). Each block holds the cryptographic hashing value of the previous block, making the blocks interdependent. This interdependency links the blocks in a chain – the Blockchain. All the network members can verify the transactions in a block and its interdependencies. If there is no consensus on a block's validity, it is not included in the Blockchain. Retroactively altering a Blockchain transaction would require altering the block that includes the transaction; however, this can only be achieved by gaining consensus and additionally altering the cryptographic hashes of every following block in the chain. Ideally, gaining this consensus is only possible for valid changes.

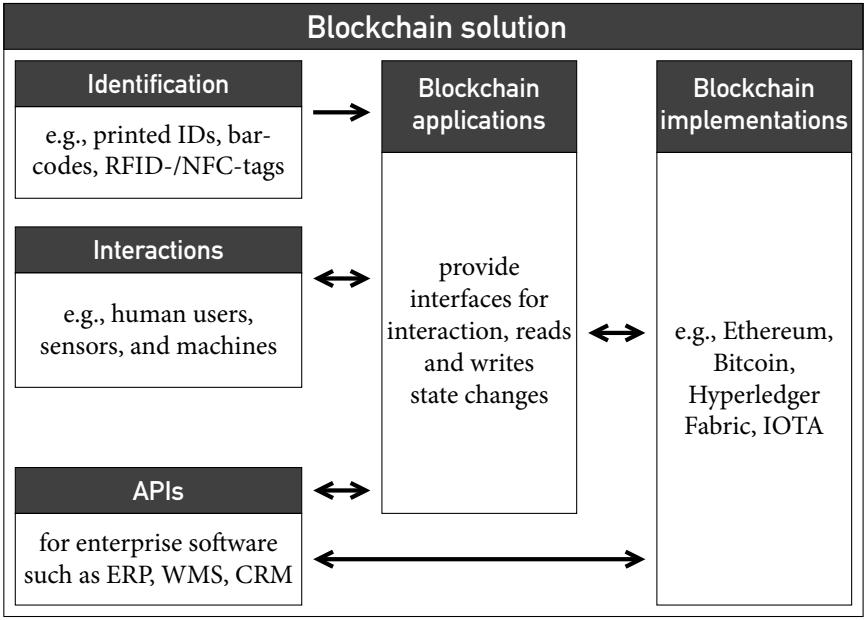


Figure 2.4: Overview of a Blockchain solution

2.2.2 Blockchain Implementations, Applications, and Solutions

In this thesis, three terms are used: *Blockchain implementation, Blockchain application,* and *Blockchain solution*. Figure 2.4 provides an overview over the terms, and the arrows indicate read and write operations. Blockchain implementations are software packages that provide a Blockchain communications protocol. Blockchain applications use the features of this software to build programs that humans or machines can use to perform an activity. *Blockchain solution* describes the overall system, including the Blockchain application, its APIs with interfaces to other enterprise software, and recording or identification devices needed for external input.

Blockchain solutions can serve as a shared data basis among companies, because the transaction data can be associated with virtual or physical goods. The transactions stored on a Blockchain are immutable, creating a data basis that both transaction

partners can trust. In practice, this makes Blockchain solutions attractive, because they may improve the information flow for SC&L functions.

It is crucial to understand that a wide range of **Blockchain implementations** exist, each featuring different functionalities, development modes, and consensus algorithms. Not all Blockchain solutions set up their implementation as genuinely decentralized, verified, or immutable. All these functionalities can be disabled or replaced by centralized services to limit reading or writing operations for data on the distributed ledger (Abelseth 2018; Huertas et al. 2018; Novotny et al. 2018). Large Blockchain-based networks suche as the Bitcoin network or the Ethereum network are publicly accessible and allow every participant to read, write, and verify transactions. Table 2.1 on the following page shows scenarios of participants limiting these operations, yielding *private permissioned* or *public permissioned* Blockchain solutions. Whether these setups qualify as a Blockchain is under discussion (Popejoy 2019). The use of a central service defeats the purpose of building trust; thus, there seems to be little reason to not use a centralized IT platform instead of Blockchains with limited permissions.

Further, some Blockchain implementations offer the possibility to program the transactions using a scripting language. These scripts are typically referred to as *smart contracts*, although they are neither smart nor actual contracts in the legal sense. Here, *smart* refers to the scripting language's ability to evaluate conditions, even using data from outside the Blockchain. The second part of the term – *contract* – indicates that the script cannot be changed later. because its code is stored immutably on the Blockchain. Some implementations use different terms; for instance, Hyperledger Fabric refers to it as *chain code*, while Bitcoin currently has no formal name for the language (Atzei et al. 2018; Manevich et al. 2018). Ethereum cofounder Vitalik Buterin notes that, in hindsight, the more technical term *"persistent scripts"* would have been more fitting (Buterin 2018).

Running the smart contract scripts can yield state changes, depending on the conditions therein, then recorded as transactions. In practice, these smart contracts enable bringing business logic to the decentralized network. They allow for the implementation of Blockchain applications such as lotteries, automatic payment releases, or asset transfers.

The most commonly used Blockchain implementations discussed for business applications are Corda, Ethereum, Hyperledger Fabric, Hyperledger Sawtooth, and Quorum (Valenta et al. 2017; Bumblauskas et al. 2020; Sund et al. 2020). Ethereum

Table 2.1: Configurations of Blockchain Access Permissions (see also Varghese et al. 2018; Scully et al. 2019). Bitcoin, Ethereum, or Dogecoin are examples of public permissionless Blockchains. The private or permissioned Blockchain configurations in the fields shaded in grey can for instance be implemented with Hyperledger Fabric or Quorum. However, the configurations marked with * are fairly theoretical and hardly useful in practice.

Permissions		Writing and validating operations	
		Not required	Required
Reading operations	Not required	*Public-permissionless** Anyone can read, write, or validate.	*Public-permissioned** Anyone can read. Only members with permission can write or validate.
	Required	*Private-permissionless** Only members with permission can read. Everyone who is allowed to read can write or validate.	*Private-permissioned* Only members with permission can read, validate, or write. Validation can be a separate role with a corresponding permission.

refers to the open, public network.[2] At the current state of development, the main differences between these implementations are the possibility to regulate public access, how consensus is achieved and the data storage options.

Cryptocurrencies remain the most popular **Blockchain application** in practice. The Blockchain implementations use cryptography to sign transactions, hence *cryptocurrency*. A Blockchain enables the users to trade directly without the need for a trusted third party, for instance a bank or a payment processor (Tapscott et al. 2016, pp. 61–62). This worldwide trade currently includes more than 11 120 cryptocurrencies with a market cap of more than €1.37 trillion (CoinMarketCap.com 2021). Cryptocurrencies, with names such as Bitcoin or Dogecoin, are examples of digital currencies or assets that use their own, specific Blockchain implementation to store the transaction states (Nakamoto 2008; Dogecoin.com 2018).

A transacted asset can also be data recording or the right to custody of a good or shipment. For instance, a Blockchain transaction of a data recording could be a temperature of a shipment container (Tian 2017; Singh et al. 2020). The Blockchain application would enable the device in this container to connect to the desired Blockchain and to record the temperature reading. Repeated readings could be useful to identify excess temperatures and enhance planning. The benefit of this Blockchain-based data storage is mainly that the records cannot be changed and that the writer is identifiable. Likewise, passing on ownership of logistics assets (e.g., swap bodies, pallets, or containers) is possible using Blockchain (Hinckeldeyn et al. 2018a; Dujak et al. 2019). Here, the Blockchain application would provide the possibility to transfer these assets and could, for instance, also release payments.

The Blockchain applications typically interface a Blockchain implementation and using the respective protocols' functionalities to record transactions or distribute smart contracts. The applications typically use smart contracts to reflect the business logic and to store states, but can also create individual transactions.

On the other hand, Blockchain applications also provide user interfaces as well as connectivity to devices, sensors, and machines that are part of the overall Blockchain solution. The user interfaces (e.g., computer or smartphone applications, or web-based services) can read and display the current states from the Blockchain, but can also pre-process input before sharing and recording it with the Blockchain.

2 While a private Ethereum setup is possible, this mode is currently mainly used for testing, since node discovery is hard.

In practice, a **Blockchain solution** uses one or more Blockchain applications and various underlying implementations (Petersen et al. 2018; Dujak et al. 2019). Beyond the application, companies may have to connect their enterprise resource planning (ERP) or warehouse management system (WMS) systems (Banerjee 2018; Swan 2018). Goods or shipping containers require labels (e.g., printed matrix codes, RFID-tags, or NFC labels) to associate them with a Blockchain entry (Alzahrani et al. 2018; Rao et al. 2020). Also, such solutions may use sensors or other Internet of things (IoT) devices to automatically record data on the Blockchain (Archa et al. 2018; Rao et al. 2020). Examples of such Blockchain solutions are the shipping information joint venture TradeLens by IBM and Maersk, the diamond tracking startup Everledger, Walmart's food tracing initiatives, or the Antwerp's port container management startup T-Mining, all of which are developing Blockchain solutions beyond simple Blockchain applications (Popper et al. 2017; Cartier et al. 2018; Jabbar et al. 2018; Stahlbock et al. 2018; Corkery et al. 2018).

The following chapters will discuss Blockchain solutions for SC&L. They specifically outline use cases, Blockchain solutions could be useful for (Chapter 3 on the next page), their perceptions in practice (Chapter 4 on page 61), and challenges toward actually adopting Blockchain solutions (Chapter 5 on page 79).

Chapter 3

Mapping the Literature on Blockchain in Supply Chain Management and Logistics

An increasing number of publications on Blockchain use in different fields reflect the ongoing evaluations and expectations of practice and research. The efforts to outline and gather possible use cases, challenges, opportunities, and possibilities have been skyrocketing. While Scopus listed four publications on Blockchain and supply chain in 2016, it listed 38 in 2017, and in 2018 more than 160. A review of the articles covering Blockchain adoption provides insights into the current state and the use cases observed in the yindustry and proposed by research. Research question 1 intends to shed light on this case:

> **RQ1:** How has Blockchain adoption in SC&L been discussed in the literature?

To comprehensively address the current state of the literature, this overall research question is further specified:

> **RQ1a:** Which use cases have been investigated for Blockchain in SC&L, for which industries, and what benefits are expected?
>
> **RQ1b:** Which research approaches have been used to investigate Blockchain use in the SC&L sector?

Addressing these questions will allow a detailed picture of the different research streams and expose gaps for further research.

The following sections contain the results of a literature study of 135 articles, including a description of the most common use cases and the current state of the literature. The chapter's last part consists of a discussion of the most prominently addressed industries, food and pharmaceutical products, and the lack of empirical data acquisition vs. theoretical discussions.

3.1 Method

The vast number of publications requires literature reviews to categorize and evaluate the scientific field's current states. The methods used to approach these reviews have different intentions and vary widely. The systematic review method stands out because it applies principles that make it robust against researcher bias (Denyer et al. 2011). While the method is established in medical sciences, it is still considered young in management research (Bastian et al. 2010; Denyer et al. 2011). Instead, narrative reviews are more common because their selective nature allows research gaps to be pointed out compactly and literature summaries to be produced. Moreover, there is no hierarchy of evidence in management research, even though it is of importance in other disciplines, owing to the existence of "a plurality of accepted methods and approaches" (Denyer et al. 2011, p. 675), substantial in other disciplines, exists in management research.

A systematic literature review approach based on Fink (2020) and Denyer et al. (2011) was adopted for this study, because it allows for investigating the investigation of the literature as a standalone research project to address research questions (Denyer et al. 2011; Munn et al. 2018; Fink 2020). This approach is also "explicit, comprehensive and reproducible" (Fink 2020, pp. 14–17) and allows for good coverage of the Blockchain-related aspects in SC&L research.

The steps taken in this study are outlined in Table 3.1 on the facing page. In the first step of this approach, an objective, and corresponding questions are formulated (Denyer et al. 2011; Fink 2020, pp. 3–4). In the next step, suitable bibliographic databases and relevant keywords are selected for the research (Denyer et al. 2011; Fink 2020, pp. 3–4). These should align with the research objective and are typically reviewed with experts (Denyer et al. 2011; Fink 2020, pp. 3–4). The keywords are

Table 3.1: Steps in the Systematic Literature Review Approach (based on Denyer et al. (2011) and Fink (2020))

Step	Tasks
1	Outline the research objective and the corresponding questions
2	Select bibliographic databases and keywords
3	Test the keywords and the analytical process
4	Analyze the retrieved articles and synthesize the results
5	Report the results

tested to determine whether they yield relevant results or if further specification is required. Further, it may be necessary to specify additional criteria to limit the scope, for instance, excluding specific publication formats or requiring specific publication levels. In a fourth step, the articles are analyzed and the information relevant to the research objective is collected. The reporting in the final step then takes these synthesized results, presents the quantitative and qualitative output, and interrelates the articles in a structured way (Denyer et al. 2011; Fink 2020, pp. 4–5).

Guided by the research questions, these steps were followed. To obtain the results, six databases for scientific papers (see Table 3.2 on the next page) were crawled; the choice of databases sought to cover as much input as possible. The search was carried out using the search string *(blockchain OR "distributed ledger") AND ("supply chain" OR logistics)* and yielded 463 results. The main research focus, *Blockchain* and the more technical term *distributed ledger* were covered by the first part of the search string. Spelling Blockchain as *block chain* yielded no different results. The second part was designed such that the full query would include papers on SC&L functions, independently of the various definitions. To keep the Google Scholar search results at a manageable level, the search in this database was limited to the articles' titles.

Table 3.2: Databases Used for the Literature Research

#	Database	Results	Date
1	Google Scholar	66	8 January 2019
2	IEEE Xplore	65	8 January 2019
3	Science Direct	15	8 January 2019
4	Scopus	202	8 January 2019
5	TEMA	41	8 January 2019
6	Web of Science	74	8 January 2019
	Total	463	

The results were then manually inspected, leading an exclusion of 328 articles in a four-step approach. Table 3.3 on the facing page provides an overview over the steps. In step a, import duplicates and unrelated full proceedings or collections were excluded. In the latter case, the individual article was always recorded separately. In step b, the publications that were not accessible through the university or online were excluded. Step c addressed the nature of the publications. Only conference papers, industry reports, or scientific articles remained part of the sample, with students' theses, conference reviews, and magazine articles excluded. The majority of articles were excluded during step d – the screening of the articles' title, abstract, and content. This mainly concerned articles that only mentioned Blockchain in SC&L as an example, for instance as part of the introduction of a technical paper.

The remaining 135 articles were manually reviewed and then categorized. Besides the research approach, for each article, the addressed industry branches and use cases were noted – many addressed more than one. The initially very detailed categorization of industries was summarized for further analysis: automotive, construction, consumer electronics, textiles, semiconductor, materials, and aircraft industry as manufacturing, and warehousing, CEP, sea freight, street transport, and railway companies as logistics.

Table 3.3: Excluded Articles

Step	Exclusion of	Excluded	Remaining
a	Import duplicates	23	440
b	Unavailable articles	39	401
c	Articles not from scientific journals, conference proceedings, or industry reports.	101	300
d	Articles that did not pass the screening of titles, abstracts, or content	165	135
	Total	328	135

3.2 Results

To answer the research questions, the articles from the sample were categorized by the addressed use cases; 17 use cases were discovered. The cases that had more than six sources are discussed in-depth in Section 3.2.2 on page 28.

The material was also reviewed for the research approaches used to investigate Blockchain use cases for SC&L. The six approaches found in the sample and the industries they address are outlined in Section 3.2.3 on page 47.

3.2.1 Overview over the Sample

The sample included articles from 2016 to 2018. Table 3.4 on the next page shows that only a few relevant articles were available in 2016, and illustrates the steep increase in publication numbers in 2017 and 2018. This development reflects the overall boom of Blockchain-driven solutions. A limited number of publications were already available as an online version in 2018 but were published in the various journals and conference proceedings in 2019. The distribution of articles between journal and conference publications was roughly even; only very few articles were from gray literature. The sample revealed no specifically popular or relevant conferences and journals. Typically, one or two articles were included from either one of 59 different conferences or 49 different journals, with three exceptions: Three articles were from the 2018 Crypto Valley Conference (Hinckeldeyn et al. 2018a; Palm et al. 2018; Wüst et al. 2018), four journal articles were from the journal *Sustainability* (Gausdal et al. 2018; Ko et al. 2018; Kouhizadeh et al. 2018; Yoo et al. 2018), and three contributions were from the journal *Logistics* (Dobrovnik et al. 2018; Francisco et al. 2018; Verhoeven et al. 2018).

The articles in the sample were authored in 42 countries, mostly in Europe, Asia, and North America. Few articles were written by authors from South America, Africa, and Australia. The institutions indicated by the authors determined the country – each country was only counted once per article. Figure 3.1 on the facing page provides an overview over the locations from which the articles received contributions as well as the methodological approaches used in these articles, illustrating the dominance of conceptual work.

Table 3.4: Included Articles by Year

Year of publication	Total	By article outlet		
		Journal	Conference	Gray literature
2016	3	1	2	0
2017	31	14	16	1
2018	101	48	50	3
Σ	135	63	68	4

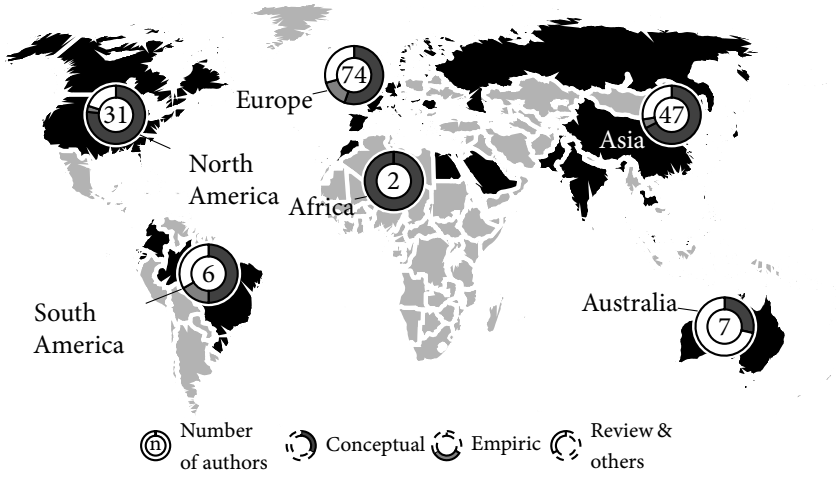


Figure 3.1: Distribution of Authors of Articles in the Sample

3.2.2 Analysis of the Use Cases

For eight use cases, enough material was found to allow for an in-depth review. Many articles discussed multiple use cases, and beyond the eight main cases, nine additional use cases were mentioned. An overview of these nine other use cases is given together in a combined Section 3.2.2.9 on page 44.

The production of food and pharmaceutical products stood out, as shown in Figure 3.2 on the facing page. Perhaps unsurprisingly, the use cases that seem most applicable to these industries were tracing, the documentation of these goods, the respective handling steps, and the prevention of counterfeiting.

3.2.2.1 Tracing Goods

Tracking and tracing of goods and materials is a vital function of SC&L. Depending on the reports between upstream and downstream SC&L functions, tracking and tracing can help when taking proactive measures to manage the material flow in case of problems (Christopher 2016, p. 204). The availability of these data not only help operations but also serve the taking of strategic decisions based on analyzing these data (Christopher 2016, p. 204; Bowersox et al. 2020, pp. 23–25).

Further, customers are increasingly interested in this information. They demand it to track the order status, and to inquire about the product or material's origin or history (Bowersox et al. 2020, pp. 23–25; Kersten et al. 2017; Min et al. 2019). Blockchain can serve as a ledger to store tracing information about materials and goods. Depending on the Blockchain implementation, access may be limited or may be fully available for upstream and downstream.

In the reviewed literature, 35 articles (see Table 3.5 on page 30) were about tracking and tracing goods. The industry-specific articles mostly addressed the pharmaceutical and food production industries. However, a large share of these articles did not address a specific industry; instead, it addressed goods tracing generally, often referring to industries as examples.

In the pharmaceutical sector, tracing back to the original manufacturer of a medicine can help to identify counterfeits. In current setups, anti-counterfeiting measures use centrally issued certificates, central databases, or interfaces on the manufacturer website (Sylim et al. 2018; Clark et al. 2018; Abelseth 2018). The Blockchain solutions could decentralize this process, empowering the downstream supply chain to

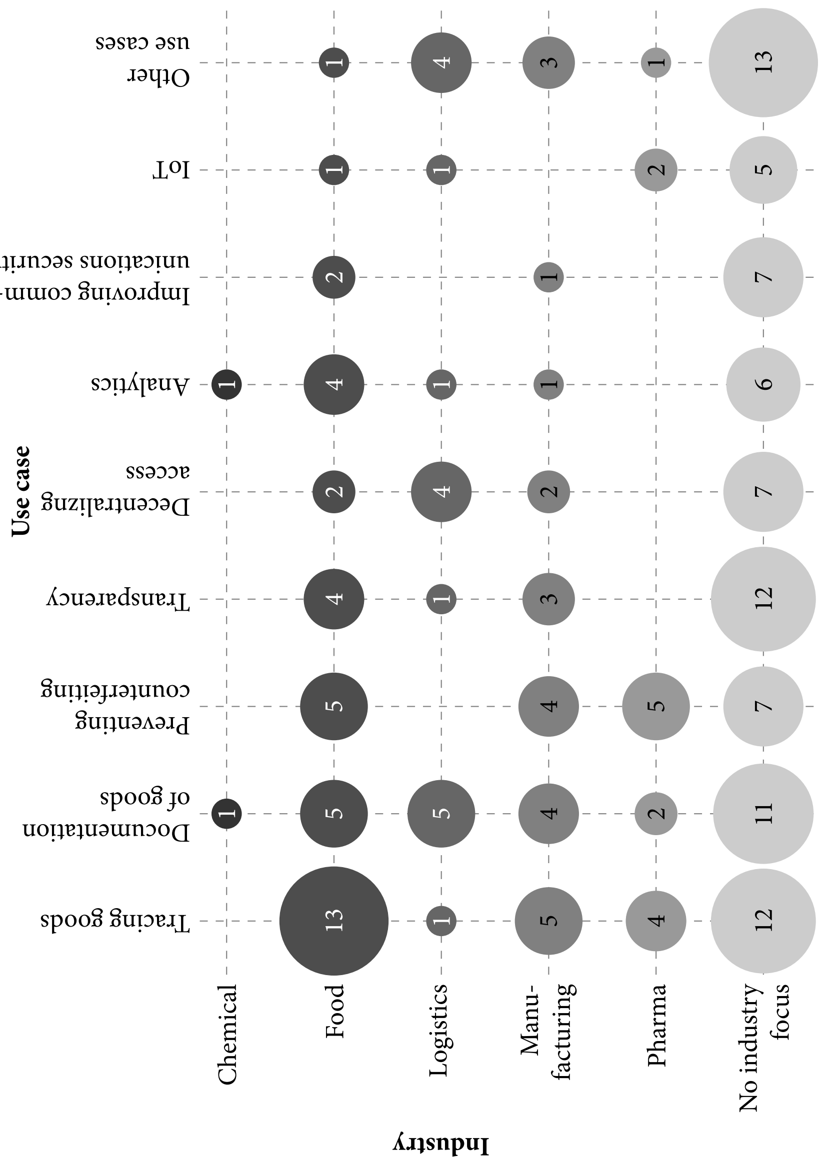


Figure 3.2: Overview of Industries and Use Cases (some articles address multiple industries and use cases)

Table 3.5: Articles Identified for the Tracing Goods Use Case

Industry	Articles	n
Food production	Baralla et al. (2019), Benton et al. (2018), Bermeo-Almeida et al. (2018), Guo et al. (2018), Hua et al. (2018), Kamilaris et al. (2018), Rejeb (2018a), Sander et al. (2018), Thiruchelvam et al. (2018), Tian (2016), Tian (2017), Tse et al. (2017), and Westerkamp et al. (2018)	13
Logistics industry	Ngamsuriyaroj et al. (2018)	1
Manufacturing	Agrawal et al. (2018), Cartier et al. (2018), Lee et al. (2017), Naidu et al. (2018), and Sharma et al. (2018)	5
Pharmaceutical industry	Abelseth (2018), Clark et al. (2018), Hulea et al. (2018), and Sylim et al. (2018)	4
No industry focus	Abeyratne et al. (2016), Casino et al. (2019), Datta (2018), Hackius et al. (2017), Hald et al. (2018), Imeri et al. (2018), Lu et al. (2017), Petersen et al. (2018), Saberi et al. (2018), Sermpinis et al. (2018), Sudhan et al. (2017), and Yoo et al. (2018)	12
		Σ 35

see and create a history of the entities that have handled a medicine. This history could also empower end-users to backtrace upon buying a pharmaceutical product (Abelseth 2018; Clark et al. 2018). Clark et al. (2018) further noted that this product history record assists compliance documentation by augmenting it with temperature records. Hulea et al. (2018) as well as Sylim et al. (2018) presented first ideas on achieving pharmaceutical Blockchain solutions generally.

The literature describing Blockchain use in food SC&L mainly covers three topics: (1) improving food safety through improved monitoring of the supply chain, (2) improving records regarding food ingredients' provenances and their processing, and (3) increasing reputation with customers by making the supply chain visible.

Food safety is an issue worldwide, with examples from smaller affected areas, such as the food-borne E.coli outbreak in Northern Germany 2011 (Buchholz et al. 2011; Robert Koch-Institute 2011), to larger affected areas such as the 2013 *horsemeat scandal* that affected at least seven countries in Europe (Madichie et al. 2017). As an accompanying setup to existing solutions, Blockchain could improve food safety by providing tracing information down to the product level (Sander et al. 2018, p. 2076; Westerkamp et al. 2018). The Blockchain setup can provide continual, universally accessible data, allowing for fully transparent monitoring of quality issues and backtracing to the responsible entity, almost in real-time (Tian 2017; Rejeb 2018b, p. 115; Tse et al. 2017, p. 1360; Westerkamp et al. 2018). While systems for tracing food exist, according to Westerkamp et al. (2018) as well as Thesmar et al. (2019), they are typically set up in a centralized way so that the supply chain participants must rely on information provided from upstream. This information is often limited (Hua et al. 2018) and, according to Trienekens et al. (2012) in (Sander et al. 2018, p. 2067), not guaranteed to be correct.

The offenders in the horsemeat scandal used horsemeat and pork to replace beef in frozen goods carried by supermarket chains. Once mixed, it was very complicated to determine which ingredients were supposed to be in the product. Downstream companies are not necessarily provided with information about the ingredients' provenance or processing (Westerkamp et al. 2018; Hua et al. 2018). Yet this information could be helpful, not only for risk mitigation in food contamination scenarios, but also for assessing whether the food production does follow the religious standards or uses the organic farming methods it claims to (Rejeb 2018b; Hua et al. 2018, p. 100; Hackius et al. 2017, p. 7). Blockchain could maintain and create more detailed, granular information for food products even in complex supply chain structures (Westerkamp et al. 2018; Hua et al. 2018, p. 100).

In light of the various food scandals and the various certification schemes, the authors in the sample found that end-customers could also value such granular information: Blockchain could be a way for end-customers to review the tracing information themselves (Westerkamp et al. 2018; Sander et al. 2018; Hua et al. 2018). A more detailed ingredients list may allow customers to make more refined purchasing decisions concerning product origin, handling, or sustainability standards (Westerkamp et al. 2018; Sander et al. 2018; Hua et al. 2018). Westerkamp et al. (2018) as well as Sander et al. (2018) asserted that such a system could increase customers' quality perceptions and, ultimately, their trust in a food product's production.

Few cases in the sample addressed tracing in specific branches of manufacturing. Agrawal et al. (2018) (Agrawal et al. 2018, pp. 202–205) introduced a use case for the textiles industry, addressing this industry's need to retroactively identify parties responsible for specific tasks. Lee et al. (2017) as well as Cartier et al. (2018) made similar cases for consumer electronics and gemstones, noting that it would be especially useful to reinforce existing SC&L systems and production claims (Lee et al. 2017, p. 20; Cartier et al. 2018, p. 222).

Authors who did not address specific industries indicated that the key advantage of a decentralized ledger could be a supply chain-overarching single source of truth (Abelseth 2018; Hald et al. 2018; Hackius et al. 2017, p. 7; Imeri et al. 2018; Lu et al. 2017, p. 27; Saberi et al. 2018, p. 7). The immutability and accessibility to all supply chain players make it possible to create an overall product history (Imeri et al. 2018; Hald et al. 2018). Supply chain-external SC&L requirements could also benefit, for instance, by providing auditors with data (Abeyratne et al. 2016), supporting sustainability claims (Saberi et al. 2018, p. 7), or increasing the reliability of reporting on dangerous goods (Imeri et al. 2018).

Only one identified article addressed the core logistics functionalities. Ngamsuriyaroj et al. (2018) conducted experiments to simulate the package tracking of CEP services through a Blockchain network. In their view, Blockchain could reduce paperwork, reducing the duplication of data and offering performance gains. However, the setup presented in the article was not extended to a larger scale.

The general idea presented in the articles is that a record of a product's history is useful. The extent of the information required and the reasons for enabling this product backtracing varies by industry. The general idea is that the current SC&L IT systems lack interaction and data exchange, and that Blockchain could provide this more global platform.

Table 3.6: Articles Identified for the Documenting Goods and Process Steps Use Case

Industry	Articles	n
Chemical industry	Takhar et al. (2018)	1
Food production	Hua et al. (2018), Rejeb (2018b), Tian (2016), Tian (2017), and Westerkamp et al. (2018)	5
Logistics industry	Hofman et al. (2017), Jabbar et al. (2018), Loklindt et al. (2018), Nærland et al. (2018), and Ngamsuriyaroj et al. (2018)	5
Manufacturing	Lee et al. (2017), Sharma et al. (2018), and Wang et al. (2017)	3
Pharmaceutical industry	Abelseth (2018) and Sylim et al. (2018)	2
No industry focus	Casino et al. (2019), Hackius et al. (2017), Imeri et al. (2018), Korpela et al. (2017), Kouhizadeh et al. (2018), Meng et al. (2018), Petersen et al. (2018), and Saberi et al. (2018)	12
	Σ	28

3.2.2.2 Documenting Goods and Process Steps

Goods typically require documentation that needs to be passed along during transfers, for instance, to record process steps or prove payment or ownership, or for compliance or customs audits (Bowersox et al. 2020, p. 213). As shown in Table 3.6, 28 articles concerning documentation of goods or process steps were analyzed.

Many descriptions of this use case, especially for food and pharmaceutical products, were similar or contained in the use case for tracing, because documentation often requires backtracking. Nonetheless, there are specific documentation cases for food production, pharmaceuticals, and manufacturing. Hazard analysis and critical control points (HACCP) approaches (e.g., ISO 22000), often mandated in the food

industry, require documentation for each process step. These documentation procedures can utilize Blockchain for document handling and actions taken along the whole supply chain (Tian 2017; Rejeb 2018b). In the chemical industry, Blockchain could support the reporting of hazardous substances by providing structured data down to the component level of products parts (Takhar et al. 2018).

Similarly, a few cases can be reported for manufacturing: In construction, Blockchain could document the building lifecycle by recording the processes with the used materials and equipment (Wang et al. 2017). Records for automobiles could contain the whole lifecycle, including repairs or data for insurance claims (Sharma et al. 2018). Overall, the industry-specific use case designs focus on recording the handling steps, making them easily accessible for downstream functionalities.

Articles that addressed the functional SC&L processes typically focused on the paper trail that accompanies shipments. As outlined in Section 4.1.1.1 on page 62 (Example case 1), the handling of these freight documents, especially the bill of lading (B/L), can be an enormous driver of cost (Groenfeldt 2017; Popper et al. 2017). The B/L is especially interesting for SC&L, because it is a paper-based tradable security. Thus, it is required to be physically transported or traded via a service provider's platform (e.g., Bolero). Presenting B/L papers allows for the claiming of custody of the indicated cargo at any time. The use of a Blockchain solution could make it more easily tradable, reduce transaction costs, and prevent forging (Jabbar et al. 2018; Nærland et al. 2018; Popper et al. 2017). Overall, Blockchain could be a "new document exchange solution" (Korpela et al. 2017, p. 4190) that works with all stakeholders' IT systems and provides a basis for a more efficient, auditable document trail (Casino et al. 2019; Korpela et al. 2017; Imeri et al. 2018).

Regardless of the industry, articles about this use case emphasized the possibility to share verifiable documents (Casino et al. 2019; Korpela et al. 2017; Kouhizadeh et al. 2018). These verified documents could be used for the automated execution of transactions between companies at a lower cost than existing solutions (Korpela et al. 2017). The verification also provides information for conflict resolution or auditable reporting downstream, even down to the end-customer (Kouhizadeh et al. 2018; Casino et al. 2019).

Blockchain has added the option of electronically signing documents, making them verifiable online without relying on a third-party service. The sample allows the conclusion that SC&L documentation based on Blockchain solutions can lower the transaction costs of sharing and provisioning documents. At the same time, these

Blockchain solutions allow organizations to make the verification trails available to more parties, providing possibilities for new business models.

Table 3.7: Articles Identified for the Preventing Counterfeiting Use Case

Industry	Articles	n
Food production	Baralla et al. (2019), Biswas et al. (2017), Li et al. (2018), Rejeb (2018a), and Westerkamp et al. (2018)	5
Pharmaceutical industry	Abelseth (2018), Archa et al. (2018), Clark et al. (2018), Mackey et al. (2017), and Sylim et al. (2018)	5
Manufacturing	Agrawal et al. (2018), Cartier et al. (2018), Islam et al. (2018), and Sharma et al. (2018)	4
No industry focus	Alzahrani et al. (2018), Boehm et al. (2018), Hackius et al. (2017), Hepp et al. (2018), Madhwal et al. (2017), Petersen et al. (2018), and Saberi et al. (2018)	7
		Σ 21

3.2.2.3 Preventing Counterfeiting

Counterfeit products are often associated with just the loss of sales for the real manufacturer. However, incorrect ingredients, parts, or materials can make counterfeits a risk for health, safety, and product image. As outlined in the previous section, Blockchain can provide necessary transparency toward supply chains. However, there are additional approaches to how Blockchain can make it hard to get fraudulent products into the supply chain.

In the review sample, 21 sources mentioned anti-counterfeiting measures (see Table 3.7) as one use case or discussed the application of Blockchain to improve these measures. The industry-specific literature mostly concentrated on outlining specific products and how they could profit from a Blockchain-backed anti-counterfeiting solution, including wine, fish, diamonds, aircraft parts, car parts, and pharmaceuticals (Biswas et al. 2017; Li et al. 2018; Rejeb 2018a; Islam et al. 2018; Cartier et al. 2018; Abelseth 2018; Archa et al. 2018). Articles that addressed no specific industry

focused only on improving existing anti-counterfeiting solutions by adding Blockchain (Agrawal et al. 2018; Alzahrani et al. 2018; Boehm et al. 2018; Hepp et al. 2018; Saberi et al. 2018).

In the food and the pharmaceutical sectors, anti-counterfeiting focuses mostly on fraudulent documentation or certificates. Rejeb (2018a) described a case for fish and noted the possibility of assigning a "misleading provenance history". Likewise, Li et al. (2018) noted that organic products' authenticity can rarely be proven when they are in the market, and suggest using Blockchain to avoid the fraudulent injection of "fake organic agricultural products" into the supply chain. The same mechanism was described for pharmaceutical products and medicine (Abelseth 2018; Archa et al. 2018; Mackey et al. 2017; Sylim et al. 2018).

Further, the authors contended that Blockchain could help make the supply chain more visible to authorities, enabling them to recognize irregularities (Abelseth 2018; Archa et al. 2018; Mackey et al. 2017). Clark et al. (2018) described Blockchain's potentials to expose product-specific authenticity features to customs authorities, allowing them to more swiftly identify counterfeit products. Making visible the authenticity features could also enable end-customers to verify products before using them (Clark et al. 2018; Sylim et al. 2018).

Enhancing the existing counterfeit prevention mechanisms is discussed in the literature and is not specific to an industry. Duplication of RFID, NFC, matrix code, or similar tags is possible, making it impossible to tell whether a product is genuine. Recording their ID on a Blockchain and recording handovers could enhance these markers' usefulness for anti-counterfeiting, because checking the tags would expose duplicates (Alzahrani et al. 2018; Boehm et al. 2018; Hepp et al. 2018; Madhwal et al. 2017; Agrawal et al. 2018; Saberi et al. 2018).

However, the authors also critically noted that this requires the consequent scanning of the products (Boehm et al. 2018; Hepp et al. 2018). Further, the Blockchain part of this system is only as good as the data. There is no inherent way for Blockchain to verify the data (Cartier et al. 2018). For instance, it's impossible to tell whether a wine bottle is a counterfeit replacement of a broken original using the data alone. In this situation, the next owner needs well-designed secondary authenticity features to cross-check genuineness.

Table 3.8: Articles Identified for the Transparency Use Case

Industry	Articles	n
Food production	Bermeo-Almeida et al. (2018), Hua et al. (2018), Tian (2017), and Tse et al. (2017)	4
Logistics industry	Jabbar et al. (2018)	1
Manufacturing	Agrawal et al. (2018), Lanko et al. (2018), and Lee et al. (2017)	3
No industry focus	Abeyratne et al. (2016), Casino et al. (2019), Hackius et al. (2017), Hald et al. (2018), Kouhizadeh et al. (2018), Meng et al. (2018), Petersen et al. (2018), Rubio et al. (2018), Saberi et al. (2018), Swan (2018), van Engelenburg et al. (2018), and Yoo et al. (2018)	13
		Σ 21

3.2.2.4 Transparency: Increasing Information Visibility

The increase in transparency owing of Blockchain's properties is of considerable interest to the SC&L community. In SC&L, increasing transparency means increasing information visibility along the supply chain, which is understood to improve supply chain performance in terms of reduced lead times, reduced lot sizes, lower transaction costs, improving transit and arrival timings, and fewer shortages (Bowersox et al. 2020, p. 89; Chopra et al. 2016, pp. 270–271; Monczka et al. 2016, pp. 735–737). Thus, it was the third most discussed use case. Table 3.8 shows the 21 related sources in the sample.

The literature has outlined two primary benefits: (1) the extension of information visibility, enabling traceability, improving customer experiences, and increasing efficiency, and (2) the enablement of digital verification of various physical certificates or documents by external organizations. While sources from food production, logistics, and manufacturing exist, most articles did not focus on a specific industry.

One idea of realizing Blockchain solutions for SC&L involves recording every step of production and transportation, and adding parts or ingredients. The acquired data would be the basis for tracing, allowing the users to have a virtual look inside the product. The authors especially noted that it would enable end-customers to check on production steps, for instance for ingredients and handling in food production, to validate original manufacturer pricing and current trade values, to check certifications, or to assess environmental impacts down to and including the raw materials (Tse et al. 2017; Lee et al. 2017; Kouhizadeh et al. 2018; Saberi et al. 2018; Abeyratne et al. 2016; Yoo et al. 2018; Agrawal et al. 2018). Kouhizadeh et al. (2018) as well as Lee et al. (2017) suggested that this end-customer demand will be a driver of Blockchain adoption. The newly gained visibility is also expected to have a normative effect on keeping promises to end-customers, but also less opportunistic behaviors by the supply chain actors, because public monitoring is now always possible (Kouhizadeh et al. 2018; Saberi et al. 2018). The increased accountability may increase the supply chain's efficiency, performance, and flexibility, because the handling information may be available to the public at some point (Saberi et al. 2018; Casino et al. 2019; Kouhizadeh et al. 2018).

The visible information can be further enhanced by verification through third parties, allowing end-customers to check whether a food product is in fact organic or whether a furniture item was indeed produced using Forest Stewardship Council (FSC) certified lumber. Tian (2017) as well as Abeyratne et al. (2016) contended that standards organizations, authorities, or certifiers would digitally sign products or user IDs to render visible their confidence in these actors. Jabbar et al. (2018) suggested that it may even be necessary that all the participants' identities be transparent, similar to the financial sector.

3.2.2.5 Decentralizing Access

Accessing data in SC&L usually means using the company's assets and querying their databases to obtain information. Especially larger companies maintain this information using ERP and other systems. These ERP systems are usually not interlinked with other companies, and including external data requires to create specific interfaces. These interfaces can be either program based to be used remotely by programs (through APIs), provide a front-end (e.g., a web service), or employ another trigger to draw data from for instance special e-mail boxes. The creation of these interfaces is an extra effort and requires maintenance.

Table 3.9: Articles Identified for the Decentralizing Access to Information Use Case

Industry	Articles	n
Food production	Hua et al. (2018)	1
Logistics industry	Jabbar et al. (2018), Kuhi et al. (2018), Nærland et al. (2018), and Ngamsuriyaroj et al. (2018)	4
Manufacturing	Naidu et al. (2018) and Sharma et al. (2018)	2
No industry focus	Alzahrani et al. (2018), Casino et al. (2019), Hald et al. (2018), Korpela et al. (2017), Rubio et al. (2018), Saberi et al. (2018), and Swan (2018)	7
	Σ	14

A key feature of using a Blockchain solution is the peer-to-peer network, which means copying the data to each node individually. Every user can run a node and connect through their own, individual interface, eventually decentralizing access. Table 3.9 shows the 14 articles from the sample that discussed this feature. Unlike in the previous section, there was no industry-specific difference regarding this discussion.

The authors mainly noted that "there is no issue with subsystem consolidation" (Hua et al. 2018, p. 100), and such systems are accessible even to stakeholders with little affinity for technology (Nærland et al. 2018, p. 11). Overall, the authors noted that Blockchain use can improve the availability of data to all players as a single source (Swan 2018). It allows each entity to work on using its own system (Rubio et al. 2018; Nærland et al. 2018); the authors thought that the use of Blockchain technology could reduce information asymmetries, improve overall information management, and standardize the information sets (Jabbar et al. 2018; Swan 2018; Casino et al. 2019).

The decentral access reduces data discontinuities and allows for the data to remain accessible for extended timespans. Sharma et al. (2018) outlined a theoretical concept for automobiles that would require data access to the car's whole lifespan, including a scrapyard and a customer unknown during the production. An analogous

Table 3.10: Articles Identified for Improving the Analysis and Measurement of Performance Use Case

Industry	Articles	n
Chemical industry	Takhar et al. (2018)	1
Food production	Tan et al. (2018) and Tse et al. (2017)	2
Logistics industry	Kuhi et al. (2018)	1
Manufacturing	Santonino III et al. (2018)	1
No industry focus	Chen et al. (2017), Hald et al. (2018), Meng et al. (2018), Petroni et al. (2018), Rubio et al. (2018), and Swan (2018)	6
		Σ 11

idea of low-level entry points by end-customers was presented by Ngamsuriyaroj et al. (2018), who designed a concept for a parcel delivery system. Hua et al. (2018) also critically noted that these open interfaces may require sophisticated solutions to maintain the manufacturers' trade secrets.

3.2.2.6 Analyzing and Measuring Performance

Information to analyze and measure the supply chains' performance is a key driver of supply chain management (Chopra et al. 2016, p. 56; Bowersox et al. 2020, p. 73). Typically, the intention is to find bottlenecks and opportunities to improve of productivity and quality (Bowersox et al. 2020, p. 25). While the evaluation processes to discover such bottlenecks are not strictly quantitative, the evaluation of the taken measures is. Processes using Blockchain allow for such evaluation because the data are continually reported and in a structured format.

In the review sample (shown in Table 3.10), aspects of performance analysis for SC&L using Blockchain were addressed in 11 articles. Overall, there was no considerable difference among the industries, besides the perceived benefits of performance improvements; for instance, the food industry profits from reduced

food spoilage (Tan et al. 2018). Instead, according to the authors, the benefits of Blockchain solutions for analysis and measuring supply chain performance are: (1) near-real-time availability, (2) possibility to manage dynamics and minimize risks, and (3) as a data basis for machine learning.

Data on a global Blockchain are available with a very short delay, which in the authors' opinion could be beneficial for the supervision of material flows (Tan et al. 2018; Meng et al. 2018; Kuhi et al. 2018). The articles suggested that the quicker availability of data could improve scheduling for logistics functions, i.e., better delivery time estimation (Kuhi et al. 2018; Meng et al. 2018) and the monitoring of perishable goods (Tan et al. 2018).

The authors expected that improving the data availability through Blockchain will reduce lead times, make deliveries faster, and improve inventory management (Tan et al. 2018; Hald et al. 2018; Kuhi et al. 2018). This improvement can minimize risks in the supply chain, as data for redirection of material flows are now available (Meng et al. 2018; Tse et al. 2017).

Analogously, using these data underpins machine learning algorithms: Blockchain solutions are intended to cover the whole supply chain; the more data are available, the more anomalies become visible. Thus, Blockchain solutions could also serve for large-scale prediction along these supply chains and increase logistics competitiveness (Rubio et al. 2018; Swan 2018).

3.2.2.7 Improving Communication Security

Tampering with communication among the partners of a supply chain or erroneous data owing to human input can lead to horrendous problems. The *Albuquerque accident* in Ericsson's supply chain is well-documented: Norrman et al. (2004) argued that more efficient communication would have led to a better understanding of the consequences of an interruption of production owing to a fairly small cleanroom fire. In 2012, the World Economic Forum (2012, pp. 10–13) noted that companies and supply chain flow increasingly depend on the continual flow and the availability of track-and-trace information, identifying the availability of this information as one of the five top vulnerabilities.

Blockchain could not only make the data available locally, but can also secure communications: 11 publications in the sample (shown in Table 3.11 on the following page) provided information about securing the communication in SC&L using

Table 3.11: Articles Identified for the Improving Communication Security Use Case

Industry	Articles	n
Food production	Tan et al. (2018)	1
Logistics industry	Liao et al. (2018)	1
Manufacturing	Santonino III et al. (2018)	1
No industry focus	Casino et al. (2019), Hald et al. (2018), Imeri et al. (2018), Kshetri (2017), Min (2018), Saberi et al. (2018), and Sudhan et al. (2017)	7
	Σ	10

Blockchain technology. The sample revealed no aspects that only apply to a specific industry. The two main use cases addressed were: (1) notary-like resistance against the alterating of records, and (2) limiting the consequences of human errors and inconsistencies.

The idea of securing data against tampering is a functionality that can serve as a notary-like addition to a data stream (Casino et al. 2019; Imeri et al. 2018; Liao et al. 2018; Tan et al. 2018). It is not necessary to store the actual data on the Blockchain: It is possible to store the hashes of sensor data or documents' contents on the Blockchain (Kshetri 2017; Liao et al. 2018). Regulators or other third parties can then use the notarized data as proof (Liao et al. 2018; Tan et al. 2018). Blockchain also reduces the risk of data loss, because it "can remove the risk of a single point of failure" (Kshetri 2017, p. 1034).

It may be possible to reduce the consequences of errors introduced by data inconsistencies introduced by human carryovers (Min 2018; Tan et al. 2018). Min (2018, p. 9) claimed that this is also a precondition for reducing fulfillment errors due to human error, because the processes can now use connected, automatic data streams.

Table 3.12: Articles Identified for the Providing Infrastructure for IoT Devices Use Case

Industry	Articles	n
Food production	Caro et al. (2018)	1
Logistics industry	Hinckeldeyn et al. (2018a)	1
Pharmaceutical industry	Archa et al. (2018) and Hulea et al. (2018)	2
No industry focus	Casino et al. (2019), Hackius et al. (2017), Kshetri (2017), Petersen et al. (2018), and Petroni et al. (2018)	5
	Σ	9

3.2.2.8 Providing Infrastructure for IoT Devices

Sensors and actors as part of internet-connected devices, the so-called Internet of things (IoT) devices, are expected to boom in the coming years. Gartner (2017) claimed that, "in 2021, 7.6 billion 'things' will ship, with 64% of them being consumer applications." The first use cases for SC&L include cold chain monitoring, location tracking, and other states of shipments (Kersten et al. 2017, p. 23). IoT devices can interact with the Blockchain like any other computer or human. Thus, IoT devices can use Blockchain as a data sink, associating the device's public key with each transaction.

In the sample shown in Table 3.12, nine articles addressed the role Blockchain could have for IoT devices. The industry-specific articles featured sample solutions targeting industry-specific challenges. These relate closely to the use cases already mentioned (e.g., counterfeiting, or tracking and tracing).

Caro et al. (2018) as well as Hulea et al. (2018) outlined sample solutions for food and pharmaceuticals, respectively. The idea in both cases was that IoT devices along the supply chain act as participants, storing monitoring and movement data on the Blockchain, making them available to downstream solutions within a short timeframe. Both authors noted that this would enhance traceability and make it auditable by consumers and regulators. This analogous concept can be used to

provide an auditable trail to combat the counterfeiting of medicines (Archa et al. 2018) or for any supply chain that can provide enough data points (Casino et al. 2019; Hackius et al. 2017; Hulea et al. 2018; Petersen et al. 2018; Petroni et al. 2018). Notably, Blockchain use also enables IoT devices to receive and provide payments for services, since they can have a cryptocurrency wallet (Casino et al. 2019; Hackius et al. 2017).

However, IoT devices' interactions with Blockchain applications or Blockchain implementations remain technically limited: Currently, more computing power is required than what simple IoT devices can provide (Casino et al. 2019; Hinckeldeyn et al. 2018a).

3.2.2.9 Other Use Cases

Beyond the presented more extensively discussed use cases, nine additional use cases were identified. These 27 articles (shown in Table 3.13 on the facing page) allow for a glimpse into the topics being discussed in sectors beyond SC&L and are an outlook on upcoming discussions. Two articles in this category solely contributed to the general discussion on when to use Blockchain in SC&L.

Five articles discussed identities: Digitally providing identities can be tricky; usually, a centralized authentication service that provides certificates is the solution. Blockchain can provide verified digital identities throughout the supply network. Blockchain can be useful in this context, because other peers can sign these identities, making them more trustworthy. These identities can also be more private, because they can be designed to allow the partial revealing of data on a need-to-know basis. In SC&L, the identities concept could identify employees of a company or who have a particular skill, to allow access, prove ownership or, for products, prove that specific companies have handled them (Gao et al. 2018; Imeri et al. 2018; Lee et al. 2017; Sermpinis et al. 2018; Wüst et al. 2018; Xu et al. 2018).

The authors of four articles thought that Blockchain could help to expose SC&L costs by going through the whole supply chain and investigating each step's impacts (Chod et al. 2018; Ko et al. 2018; Lu et al. 2019), explaining that this allows companies to realize cost savings and describe their financial abilities for trade and bank credit (Casino et al. 2019; Chod et al. 2018).

Further, some authors described how Blockchain could help with automation, for instance, of warehouse replenishment, or by interconnecting logistics actors

Table 3.13: Articles Identified for the Other Use Cases

Use case	Articles	n
Providing identity	Gao et al. (2018), Lee et al. (2017), Sermpinis et al. (2018), Wüst et al. (2018), and Xu et al. (2018)	5
Exposing cost and financial abilities	Casino et al. (2019), Chod et al. (2018), Ko et al. (2018), and Lu et al. (2019)	4
Automation of logistics processes	Casado-Vara et al. (2019), Hinckeldeyn et al. (2018a), Hofman et al. (2017), and Petersen et al. (2018)	4
Connecting ERP systems	Banerjee (2018), Korpela et al. (2017), and Tönnissen et al. (2018)	3
Middleware	Hofmann et al. (2017), Tönnissen et al. (2018), and van Engelenburg et al. (2018)	3
Exposing SC&L sustainability efforts	Kouhizadeh et al. (2018), Saberi et al. (2018), and Tan et al. (2018)	3
Exposing SC&L governance	Casino et al. (2019) and Hald et al. (2018)	2
Spare parts supply chain	Madhwal et al. (2017)	1
General discussion and theory-building	Dujak et al. (2019) and Treiblmaier (2018)	2
		Σ 26

and utilities (Hinckeldeyn et al. 2018a; Hofman et al. 2017; Casado-Vara et al. 2019). Enterprise resource planning (ERP) systems could be interconnected across companies to automate sales and data exchanges (Banerjee 2018; Tönnissen et al. 2018). Blockchain could serve as an infrastructural component or as a middleware for cross-company supply chain integration or inventory-sharing (Hofmann et al. 2017; van Engelenburg et al. 2018).

A few authors also provided insights into how Blockchain could address governance issues in SC&L and render sustainability efforts more visible. Especially ecological aspects could be quantified easier through Blockchain use, as Saberi et al. (2018) (Saberi et al. 2018, p. 14) proposed: "Blockchain technology in the supply chain will more effectively manage economic and environmental (ecological) sustainability rather than social sustainability in the supply chain."

Also, notable is the meta use case of the *spare parts supply chain* outlined by Madhwal et al. (2017) in a case study on aircraft spare parts. It combines the need for immutable historical data about the parts, the need for anti-counterfeiting, and the link to technical documentation.

In a more general setting, Treiblmaier (2018) provided research approaches required to embed Blockchain in SC&L "in the development of middle range theories by using four well-established and complementary theories (principal-agent theory (PAT), transaction cost analysis (TCA), the resource-based view (RBV) and network theory (NT).)" (Treiblmaier 2018, p. 554). In search of "key features of Blockchain applicable in the supply chain" and next steps in development, Dujak et al. (2019, p. 23) found that Blockchain's properties "could assure its place as an important support and upgrade in supply networks" (Dujak et al. 2019, p. 42). Both articles noted the necessity for further in-depth research so as to clarify whether "the blockchain is an overemphasized solution looking for the problems it could solve" (Dujak et al. 2019, p. 42) and to gather academic knowledge, as opposed to industry projects of which "gains in experience are rarely shared" (Treiblmaier 2018, p. 555).

3.2.3 Analysis of the Research Approaches

In this section, the approaches researchers are applying and the industries they are focusing on when investigating Blockchain in SC&L are reviewed. The analysis will allow the mapping of the current state of the field and the outlining of research directions.

Each article was assigned to one research approach category, yielding six categories: The category *empirical* included articles that collected new data in some form. *Conceptual* articles described how Blockchain properties could be useful in SC&L. The *test runs* category is an extension of the former, with the difference that these authors used a Blockchain solution or Blockchain application to assess the concept. Articles included in the *review* category analyzed the literature as their primary research objective. In contrast, those in the *theory* category addressed the possible embedding of Blockchain-related concepts into general SC&L theory. *Technology*-related articles discussed the advancement of Blockchain implementations' technological features in the context of SC&L use cases.

Figure 3.3 on page 51 shows that most of articles did not have an industry-specific focus and used a conceptual approach. The conceptual work often focused on the possibilities of Blockchain in SC&L following the use cases outlined in Section 3.2.2 on page 28 rather than specific industries (Hepp et al. 2018; Petroni et al. 2018; van Engelenburg et al. 2019). The industry-specific concepts look at the use cases in specific contexts, for instance the use case *tracing* is applied to food (Galvez et al. 2018) or pharmaceuticals (Abelseth 2018; Kim et al. 2018b).

Although most articles dealt with more than one use case, Figure 3.4 on page 52 shows the majority of conceptual work when mapping the research approaches to the use cases. The conceptual, empirical, and test run approaches primarily concentrated on the use cases of tracing and documenting goods; both functions are very close to core functionalities needed for SC&L. Conceptual work on tracing illustrate Blockchain's feasibility, for instance, by outlining how Blockchain could support food safety (Tian 2017; Tian 2016; Tse et al. 2017) or for "helping the government track, monitor and audit the food supply chain and helping manufacturers to record the transactions in authenticity" (Tse et al. 2017, p. 1360). The empirical articles that discuss traceability were all quantitative and provided experts' opinions (Petersen et al. 2018; Hackius et al. 2017), professionals (Thiruchelvam et al. 2018), or consumers (Sander et al. 2018). The authors that conducted test runs for using Blockchain solutions for tracing presented first prototypical concepts in their

articles: For instance, Guo et al. (2018) from the IBM China Development Lab presented a *Hyperledger Fabric*-based food safety app for meat, involving farmers, food processors, retailers, and consumers. Hulea et al. (2018) presented a *Hyperledger Sawtooth*-based tracing platform for a cold chain for pharmaceuticals.

A more detailed analysis of the articles using an empirical research approach (n=14) (shown in Table 3.14 on the facing page), revealed that most focused on specific use cases or industries. Only four articles (Petersen et al. 2018; Hackius et al. 2017; Queiroz et al. 2019a; White 2017) discussed overarching aspects that allow possible conclusions regarding barriers and opportunities Blockchain could have for SC&L.

The remaining articles typically investigated very particular cases or industries. Marine shipping received special attention in the qualitative empirical research (Jabbar et al. 2018; Loklindt et al. 2018; Nærland et al. 2018; Gausdal et al. 2018), driven by the huge public interest in Maersk's TradeLens project. The articles focused on collecting insights from practice to identify whether Blockchain meets companies' expectations (Jabbar et al. 2018; Gausdal et al. 2018). Some of this empirical research focused on quantitative testing of the perceptions of Blockchain's benefits in single industry chains in specific countries, for instance coffee in Burundi, automobiles in Thailand, or meat in the United Kingdom (Supranee et al. 2017; Thiruchelvam et al. 2018; Sander et al. 2018). One article investigated the possible benefits of the combination of Blockchain with ERP systems (Tönnissen et al. 2018). Two articles investigated seemingly random populations with the goal of identifying requirements for companies that intend to use Blockchain (Lacity 2018; Korpela et al. 2017).

Table 3.14: Articles in the Sample Using an Empirical Research Approach (n=14)

Article	Method	Focus
Gausdal et al. (2018)	Case study of the industry with expert interviews (n=7)	Norway's offshore industry
Hackius et al. (2017)	Descriptive analysis of barriers, expectations, and use case examples (n=151)	SC&L experts
Jabbar et al. (2018)	Case study addressing three companies as separate cases with expert interviews for each case (total n=15)	Maritime shipping industry
Korpela et al. (2017)	Case study addressing quantitative and qualitative data collection in three focus group workshops (n_1=18, n_2=18, n_3=31)	A consortium of Finnish businesses
Lacity (2018)	Case study comparing company cases (n=3)	No specific focus
Loklindt et al. (2018)	Expert interviews (n=20)	Use of Blockchain for sea freight shipping documentation
Nærland et al. (2018)	Technical demonstration with feedback from experts (n not documented)	Use of Blockchain for sea freight shipping documentation, specifically the B/L
Petersen et al. (2018)	Comparison of collected cases (n=49)	SC&L companies
Queiroz et al. (2019a)	Test of a TAM based model using PLS (n=738)	SC&L experts from the U.S. and India
Sander et al. (2018)	Test hypothesis regarding a Blockchain-based tracking-and-tracing system using PLS (n=141)	Consumers of animal meat

continued on the next page

(Cont.) Table 3.14: Articles in the Sample Using an Empirical Research Approach

Article	Method	Focus
Supranee et al. (2017)	Test of hypotheses regarding trust and benefits using Blockchain in the supply chain with factor analysis using Variomax rotation (n not documented)	Automotive industry in Thailand
Thiruchelvam et al. (2018)	Descriptive analysis (n=66)	Burundi coffee production supply chain
Tönnissen et al. (2018)	Content analysis of blogs and magazines (n=35), sample case study (n=1) based on public data, and a questionnaire with open questions (n=11)	ERP systems for automatic purchasing
White (2017)	Delphi study (n=90)	Business management experts (practitioners and academics)

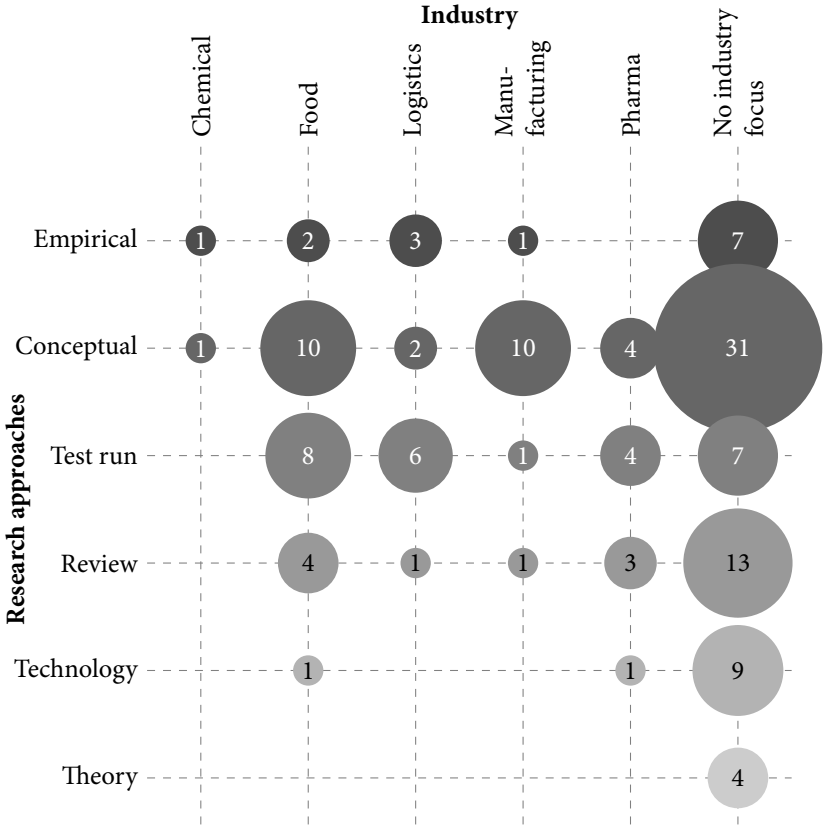


Figure 3.3: Overview of Research Approaches and Industries

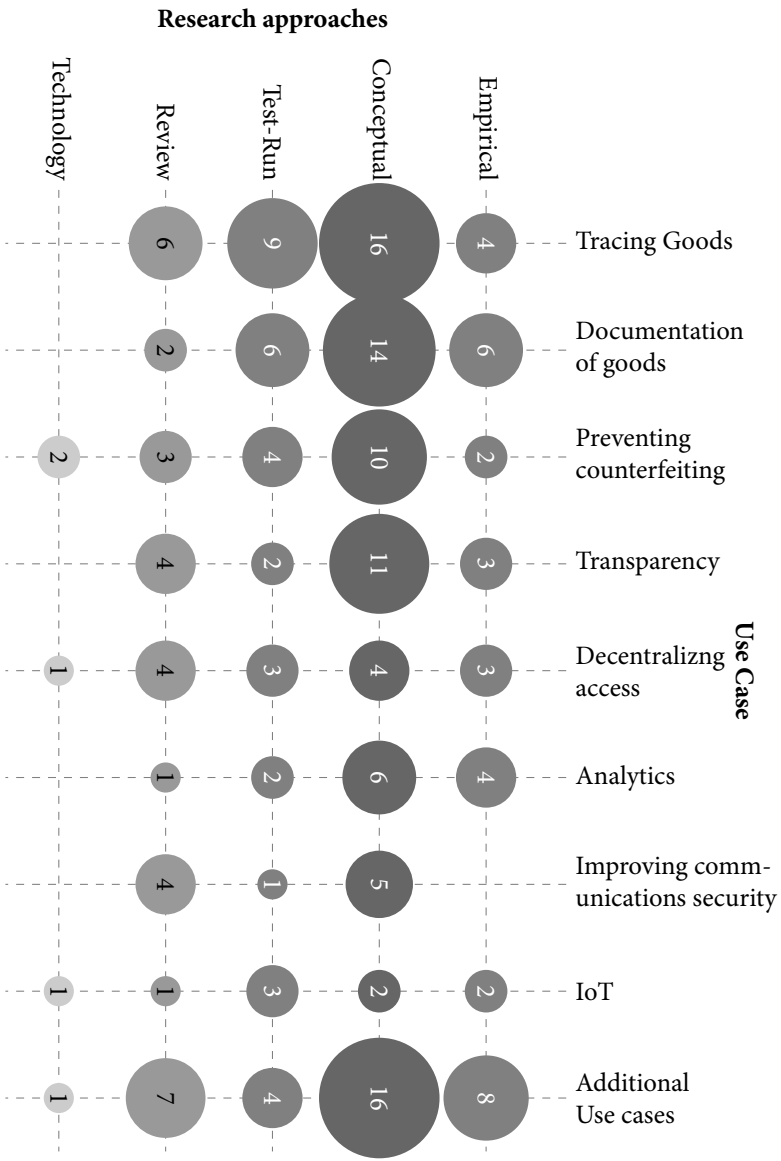


Figure 3.4: Overview of Research Approaches and Use Cases (some articles address multiple use cases and approaches)

3.3 Discussion

The tracing of goods and the documentation of products' handling processes were the most discussed use cases, as outlined in section 3.2.2. Decentralization and immutability, two key features of Blockchain records, are necessary for and utilized by these use cases. The most-addressed industries were food production and the production of pharmaceuticals. Both industries already have an advanced reporting standard, which is challenging to maintain and could be made more attractive by making it accessible to end-consumers.

The literature on Blockchain use for tracing has concluded that the granular insights into the history of the parts and their ingredients is beneficial. Use across the supply chain could enable real-time tracking as the tracing information stacks up with the transactions. An end-to-end use of these approaches across the whole supply chain is more effective than a partial realization; it is only if upstream can consider decisions made downstream and vice versa that the full potential unfolds (Waters 2003, p. 9; Christopher 2016, p. 165).

The application of the technology will also depend the industries' goals. For instance, the results suggest the provenance of the final product and its ingredients is more relevant for the food industry. On the other hand, the pharma industry is more inclined toward using tracking as part of its anti-counterfeiting strategy.

The first step to an elaborate track-and-trace system could be retrofitting existing documentation processes with Blockchain. In the sample, the use cases about using Blockchain for documentation, focused on the possibility of adding electronic verifiability to existing workflows. Documents can then be digitally shared and signed by many parties beyond a company's network (e.g., authorities, traders, or other stakeholders) while maintaining a document's integrity. Today, an intermediary is required to provide trust that the signatures are correct and the documents are unaltered. However, in a Blockchain solution, mitigating forgings of signature streams or preventing unauthorized changes to a document are possible without a third party.

Depending on the design, these signature chains increase transparency and make it possible to zoom in to the building blocks, parts, and ingredients of products and supply chains. Such zooming in could drive accountability owing to the increased visibility and because it's possible to check the attached certificates for validity. Some

authors (e.g., Lee et al. (2017), Saberi et al. (2018), and Kouhizadeh et al. (2018)) believe that this aspect will foster customer relationships.

End-customers and all supply chain participants could benefit from the exposure of authenticity features. Blockchain solutions are a supplemental tool that could provide this exposure and prevent the creation of duplicates of ID tags for existing anti-counterfeiting technologies. Notably, overall, the authors discussed products that are either luxury items or products for which counterfeits could have horrific implications.

Regardless of data availability, overarching ontologies will be needed to describe the parts or compositions in ever-more granular ways to standardize the data's readability for further processing. While a great many ontologies exists, there has been very little research into the interactions between Blockchain transactions and ontologies (Kim et al. 2018a).

Beyond these more functional aspects, the authors in the sample also suggested supportive functionalities: Local access to the data, communications security, and infrastructure for IoT devices. The low-level access and the possibility for all companies to use their specific software to work with synchronized, up-to-date data locally is an advantage of Blockchain technology in SC&L. Further, having the companies work on the same datasets enforces standardization and information continuity across all users and thus beyond company borders. In the future, interaction with partners across the supply chain could require fewer individual interfaces.

This enforcement of structuring also serves to secure communication against media discontinuities; on the other hand, tamper-resistance is built in. Even in simple setups, the storage of hashes and the possibility of following up on these can secure data streams along a supply chain.

IoT devices will be a major driver of the data streams. A centralized service such as a data sink for the widespread use of these devices would be expensive to administer and prone to manipulation. Blockchain could offer IoT devices a decentralized data sink. IoT devices embedded in supply chains could offer their sensor data or their actuator options on-demand, enabling business models based on variable costs. The use of cryptocurrencies or similar tokens would make these trades fully independent of a central entity.

Further, Blockchain transaction data can serve analytics and performance measurement for SC&L. For instance, if the transactions are available in a dashboard, it does not matter if it's a short view, a long-time assessment, or an extensive model derived

through machine learning. The benefit stems from the continual availability of structured and well-defined data. From a more global perspective, Blockchain may improve companies' supply chain reporting. Automatic provisioning of reported data allows the near-term followup on financial, sustainability, and governance initiatives.

The topics of identity provisioning through Blockchain and self-sovereign identity (Mühle et al. 2018) are complex and require a separate discussion beyond SC&L. Especially the identities of IoT devices and sensors must be discussed as soon as their data points become part of the decision-making for supply chains. However, identity provisioning will be a requirement to distinguish SC&L actors. Especially the re-use of identity information in different contexts provides additional room for efficiency improvements or cost reductions.

The various other use cases outlined in Section 3.2.2.9 on page 44 illustrate the vast range of applications for Blockchain in SC&L. While much conceptual work already exists, the discussion of specific cases – such as the spare parts supply chain – can uncover specific requirements. More articles that build and test run Blockchain solutions are needed to fully describe the particularities of the many use cases and the industry-specific coupling of Blockchain and supply chain. This additional knowledge can then help build more universal Blockchains solutions.

Analysis of the articles also showed that conceptual approaches prevailed. These can simply build on the idea that Blockchain could be applied in SC&L without requiring additional data collection. These greenfield approaches illustrate how young the Blockchain-related research is because practical Blockchain applications to compare to or question the results are lacking. Overall, whether these approaches sufficiently consider companies' practical requirements remains an open question.

Likewise, the empirical evidence and the knowledge gathered from practice are limited, because practical cases are only just emerging. Most of the empirical articles have focused on specific supply chain segments, logistics functions, or business cases, with the overall intent to capture how companies perceive Blockchain in practice (also see Table 3.14). Lacity (2018) was the only source to present considerations companies should make when looking for a Blockchain application; however, these were derived from cases that are still in a prototype phase and remain at the application level. Generally, there has been little discussion of the overall changes Blockchain could cause for SC&L and how supply chain-overarching Blockchain solutions could be achieved. The inclusion of more knowledge from experts and practitioners with SC&L experience could strengthen this insight.

3.4 Preliminary Conclusions

The overall lack of insights into Blockchain solutions in practice has the major implication that more knowledge must be gathered. However, the literature review's discussion and results allow deducing a few additional implications for research and management practice. Moreover, some limitations and opportunities for further research are outlined. In Chapter 6 on page 153, the findings will be integrated with the results from Chapter 5 on page 79 and Chapter 4 on page 61.

3.4.1 Implications for Research

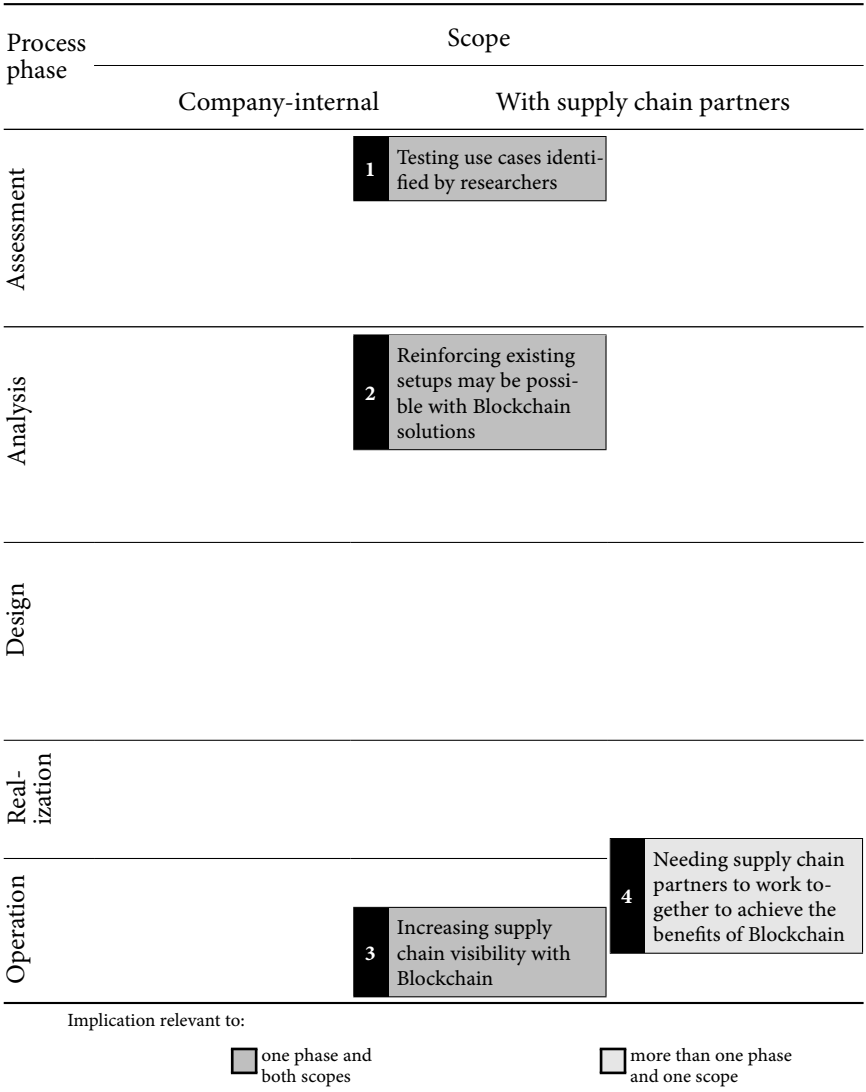
Regarding the state of the research, very few articles have addressed theory-building: Only four in the whole sample, despite the broad search term. Investigations of how existing theories explain the adoption of Blockchain solutions could improve the understanding of these processes (Treiblmaier 2018; Bhattacharyya et al. 2018). While early-phase approaches exist, they have not been tested with data (Bhattacharyya et al. 2018; Francisco et al. 2018; Verhoeven et al. 2018; Chod et al. 2018).

The research should extend the available information about use cases and sample Blockchain solutions in practice. In the sample, 58 of 135 articles used a conceptual approach and were rather descriptive, and there were few scientifically published example solutions. Especially the additionally identified *other* use cases (see Section 3.2.2.9 on page 44) warrant in-depth research to either strengthen or reject them.

3.4.2 Implications for Management

The literature review illustrated the many possibilities Blockchain solutions could bring to SC&L practice with benefits beyond simply using new software. Especially the conceptual work calls for test runs in practice. A clear next step will be to consider which of the use cases identified by researchers are even feasible in practical tests (1 in Table 3.15 on the facing page). Companies likely already have some alternative solutions for many use cases in place. The aspects from the conceptual work in the review may allow them to consider Blockchain for these. For instance, companies that already have tracing solutions in place because they work with highly valuable or perishable assets could experiment with adding Blockchain applications. Blockchain solutions may improve or reinforce existing setups (2 in Table 3.15 on the next page).

Table 3.15: Embedding the Implications (1-4) for Management in a Process Model for Business Integration by Nedbal (2013).



The increased visibility of the SC&L functions could allow for performance optimizations and improve data quality generally (3 in Table 3.15 on the preceding page). Identifying bottlenecks and unnecessary steps can provide companies with a short-term return-on-investment for implementing a Blockchain solution. Additionally, scenarios, such as a product recall or a food contamination investigation, may be carried out quicker and more precisely.

However, notably, the scientifically reviewed practical tests are very limited, and there have been very few reports of possible barriers or best practices. Further, these solutions cannot be implemented by one company alone, since parts of the supply chain need to work together to achieve these benefits (4 in Table 3.15 on the previous page).

To provide better insights into the managerial implications' consequences, they were embedded in the process model for business integration by Nedbal (2013). The model's phases are shown in column 1 of Table 3.15 on the preceding page. The implications derived in each chapter are then introduced in the figure based on the phase and the scope they address.

3.4.3 Limitations and Opportunities for Further Research

The interpretation and comparison of the results should consider some limitations. The cutoff date for sampling was chosen due to practical constraints, even though the field was rapidly advancing. Publications using a later sampling date will likely consist of new use cases and possibly close the methodological gap. A repetition of the study for the coming years is advisable.

The results included in the sample did not need to fulfill the quality standards of ranked scientific publications. The goal was to include as many use cases and research approaches as possible. Additional quality criteria could largely reduce the sample. The steep increase in publications, especially in 2019, will likely require the specification of cutoff criteria for future studies.

In the future, use cases that are feasible in practice will be more clearly defined. In this study, the use cases were selected and described in an explorative manner and based on the discovered literature. Some of these use cases partly overlap. While the literature was not used exclusively for one use case category, future research may use different definitions for these categories, making comparison difficult.

Chapter 4

Surveying Anticipations of Blockchain in Supply Chain Management and Logistics Practice

"I became increasingly convinced that maybe we were onto the holy grail." (Popper et al. 2017) – these words by the former Vice President of Walmart Food safety are just one example of the SC&L community becoming aware of Blockchain technology. Increasingly, many SC&L pioneering innovators were under the impression that Blockchain could improve not only tracking and identification technologies, but also SC&L processes generally (O'Marah 2017; Dickson 2016). For instance, in their Harvard Business Review article, Casey et al. (2017) expected cost savings through "potential efficiency improvements, enabled by previously unavailable information" viewing Blockchain technology as "a much-needed platform for economic renewal." In this light, Blockchain technology was greeted by huge expectations. Nonetheless, among logisticians – especially those from small and medium-sized enterprises (SME) – Blockchain was little known (Kersten et al. 2017).

In 2016 and 2017, numerous reports about large companies' intentions to use Blockchain have emerged (Hackett 2017; Hackett 2016; Underwood 2016; Lomas 2015; Popper et al. 2017). These reports raise the question how practitioners perceive Blockchain for SC&L, especially which applications they find favorable and what barriers they expect for Blockchain solutions. Thus, the following research question is derived:

RQ2: How have practitioners perceived Blockchain's benefits and prospects in SC&L?

In this chapter, representative examples of possible application areas will be investigated. A web-based survey is introduced, the prospects and challenges of Blockchain in SC&L are outlined, and differences between of participant groups are highlighted. The chapter concludes by outlining implications for researchers and managers, as well as limitations that should be considered when interpreting the results

4.1 Method

The evaluation of the use case examples provided by industry experts was – among other questions – investigated using a web-based survey. This section describes the investigated use case examples and the data collection setup.

4.1.1 Use Case Examples

Chapter 3 on page 21 illustrated the wide range of concepts regarding Blockchain in SC&L. Those chosen for this investigation represent the facets of the concept space. They are also representative of four major ideas of promising prospects recognized by practitioners at the time of the study (Popper et al. 2017; Tian 2016; Underwood 2016; Hackett 2017). Table 4.1 on the facing page summarizes the use case examples and shows how they were introduced to the study participants. A more detailed description of these cases follows in the next sections.

4.1.1.1 Use Case Example 1: Ease the Paperwork Processing in Ocean Freight

International container transports have a long trail of paperwork associated with them. For instance, shipping refrigerated goods from East Africa to Europe requires stamps and approvals from around 30 people and organizations that must interact on more than 200 occasions. Also, documents such as the B/L may be subject to fraud (Popper et al. 2017). The cost of the trade-related paperwork processing is estimated to be between 15% and 50% of the costs of physical transport (Groenfeldt 2017; Popper et al. 2017). To tackle such process inefficiencies and digitalize paper records, IBM and Maersk joined forces in 2015. They eventually settled on a permissioned Blockchain solution to connect the vast global network of shippers,

Table 4.1: Descriptions of the Use Cases as Shown in the Web-Based Survey

#	Use case example	Brief description
1	Ease paperwork processing	Global container shipping still involves a lot of paperwork – costing time and money. Also, paper-based freight documents like the bill of lading are prone to loss, tampering, and fraud.
2	Identify counterfeit products	Counterfeit medicine is a growing problem for pharmacy supply chains. This especially pertains to expensive, innovative medicine like cancer drugs. Pharmacies have to make sure to sell "the right thing" to the consumers.
3	Facilitate origin tracking	In the food supply chain, foodborne out-breaks are a challenge for retailers. They have to get a quick overview of where the food came from and which other products are also affected and have to be removed from the stores.
4	Operate the Internet of Things	More and more logistics objects are equipped with sensors that generate data along the supply chain – e.g., about the status of a shipment. This data has to be stored in an immutable, accessible way.

carriers, ports, and customs. The first round of pilots in 2017 succeeded. In these pilots, every relevant document or approval was shadowed on the Blockchain, i.e., the legacy IT systems were not replaced but augmented. Every partner could gain full visibility on a container's status through a standardized interface (Allison 2017). Until the end of 2017, Maersk hoped to shadow one in seven container shipments on the Blockchain – around 10 million per year (Groenfeldt 2017). However, the problems associated with extensive paperwork are not limited to this specific use case but hamper all trade flow types (Chu et al. 2016; Morabito 2017).

4.1.1.2 Use Case Example 2: Identify Counterfeit Products

The provenance of high-value items often relies on paper certificates, which can be tampered with or get lost. Whether a diamonds certificate is genuine or fake,

and whether it was stolen, are it is not always easy to determine. The same holds true for expensive wine, watches, or handbags (Lomas 2015). Since for instance, a diamond's serial number can easily be re-cut, the startup Everledger takes an alternative approach, recording 40 data points that uniquely identify a diamond. Using these publicly available records on the Blockchain, a potential buyer can determine if the seller is in fact the diamond's actual owner and can also can ensure that they're not buying a *blood diamond* mined in a war zone (Underwood 2016). Everledger plans to extend this fraud detection system into a provenance platform for many high-value items (Yarm 2019; Lomas 2015). In the medical sector, counterfeit medications are a known problem that can have lethal consequences if patients do not receive their treatment as prescribed (Mackey et al. 2017). Blockchain could improve patient safety by establishing supply chain transparency, from manufacturers through wholesale and pharmacies to the individual patients. Through barcodes or other AIDC technology, patients could be empowered to check whether they have received the medication (Mackey et al. 2017; DeCovny 2017). Blockchain is thought to make it much harder to tamper with products or to smuggle products of illegal origin (Sutherland et al. 2017; Apte et al. 2016; Morabito 2017). This development is reflected in the market, as the number of startups in this field is vastly increasing; examples similar to Everledger include Bonafi (est. 2018, U.S.), NoFake (est. 2017, Singapore), Luukso (est. 2017, Germany), Luxtag (est. 2016, Malaysia), and Verisium (est. 2017, Russia).

4.1.1.3 Use Case Example 3: Facilitate Origins Tracking

A food-borne disease outbreak can give retailers a hard time figuring out where the harmful ingredients originated and which stores they were delivered to (Tian 2016; Sander et al. 2018; Tian 2017). Especially in international trade, it can take weeks to track down to the contamination source and restore consumers' confidence in food safety (Popper et al. 2017; Sander et al. 2018). To facilitate origin tracking for food items, Walmart partnered with IBM in 2016. Like with Maersk, Blockchain is used to augment the supply chain partners' existing IT systems through a transparent, superordinate ledger, tracking food items' movements. This shared forum is considered a substantial improvement over Walmart's earlier trials involving barcodes or AIDC technology, solutions that required central databases and trust between the participants (Hackett 2017; Hackett 2016). In some first pilots, Walmart and IBM digitally tracked national movements (pork from small Chinese farms to Chinese stores) and international movements (farm produce from Latin America to stores

in the U.S.) (Popper et al. 2017). In these pilots, data such as the farm origin, batch numbers, factory data, processing data, expiration dates, and shipping details were written on the Blockchain, instantly becoming available to all the network members (Shaffer 2017). During an outbreak of food-borne disease, these data enabled Walmart to track down an origin within seconds. Ultimately, Walmart believes Blockchain could reduce food waste if the newly available data on shelflife data are used as a parameter for supply chain optimization (Shaffer 2017).

4.1.1.4 Use Case Example 4: Operate the Internet of Things

In IoT, everyday objects are equipped with electronics and can exchange data via the Internet. A Gartner report estimated that there will be more than 20 billion connected *things* by 2020 (Gartner 2015). However, the current Internet architecture with its server infrastructure may not handle such a large number of devices and data (Eastwood 2017). Single servers represent a single point of failure and raise data security concerns. The public Blockchain ledger is considered a solution to reliably connect and manage IoT devices (Pilkington 2016; Christidis et al. 2016; Mittal et al. 2018). Given the large number of devices that could become IoT devices (e.g., vehicles, containers, pallets), logistics may be a promising field for IoT and Blockchain (Mittal et al. 2018; Zheng et al. 2017). Several large companies have started working in this area. For instance, Walmart was recently granted a patent that seeks to improve last-mile logistics by connecting delivery drones to the Blockchain (Hackett 2017). Such IoT devices connected to the Blockchain could also be provided with a digital currency, which would enable them to interact autonomously with other parties and, through smart contracts, to pay fees and duties by themselves, for instance for priority access to restricted air corridors (Hinckeldeyn et al. 2018b; Christidis et al. 2016).

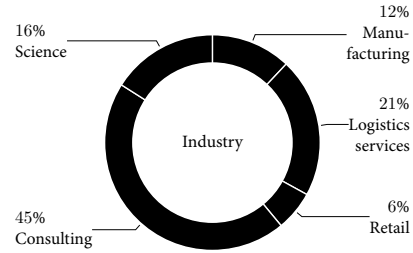
4.1.2 Setup and Data Collection

The survey was implemented using Typeform and had four key parts: Part 1 inquired about the participants' general knowledge of SC&L and Blockchain. The intention was to use this to distinguish between participants who are more knowledgeable than others. Second, the four use cases examples were introduced. The participants evaluated Blockchain's benefits and its adoption likelihood for each use case example. For the study, this rating served as a comparison between the cases. In Part 3, the participants answered questions about their general opinion on the primary beneficiaries of Blockchain in logistics, likely barriers to adoption, and the expected effects on established logistics processes. A closeout part recorded job and company details.

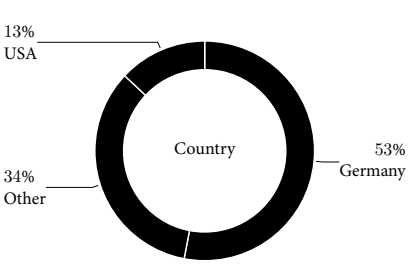
The data collection took place between 28 April and 13 June 2017. The participants were mainly recruited via social media, for instance, posts about logistics and Blockchain interest groups on LinkedIn, Xing, or Meetup. The BVL (Bundesvereinigung Logistik e.V.) shared the call for participants through its social media channels. Participation was incentivized by promising a small donation to one of two charitable organizations.

Each use case example was evaluated using two seven-point Likert scales. The other question used 10-point Likert scales. The full questionnaire can be found in Appendix B on page 191 and the scales for the quantitative study in Appendix A on page 189.

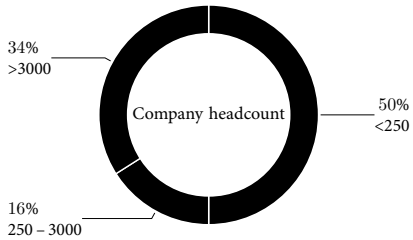
Especially for anonymous Internet surveys, thorough examination of the data is advised to identify careless responses (Meade et al. 2012). Of 155 initially collected datasets, four were excluded from the analyses owing to apparent answer patterns or to being nonsensical. The statistical analysis was prepared using IBM SPSS Statistics, following the guidelines of Hair et al. (2009). The job levels were separated into three categories: domain experts (n=89), middle managers (n=21), and chief officers (n=33), based on the information supplied by the participants. Eight participants provided no information. Data were described and tested where applicable using the Kruskal-Wallis test with pairwise comparison to compare groups and Kendall's τ to identify correlations. Significance was accepted at the 5% level; for multiple tests, the significance levels were Bonferroni adjusted.



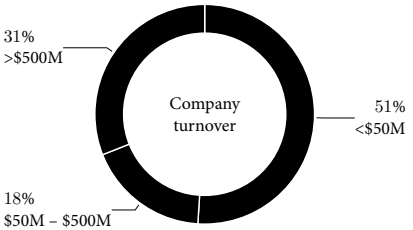
(a) Industries Represented in the Sample



(b) Countries Represented in the Sample



(c) Headcount of Companies in the Sample



(d) Turnover of Companies in the Sample

Figure 4.1: Participants and their Companies – Overview of the Sample (n=151)

4.2 Results

The study results are presented in the following, mainly by providing the mean values of the participants' assessments. The differences between the participant groups are also explored.

Figure 4.1 provides an overview over the 151 participants: The majority worked in consulting, followed by logistics services and sciences. More than half came from Germany, followed by the U.S., Switzerland, and France. Most participants worked for SMEs with a headcount of under 250 people and an annual turnover of less than $50M. This distribution was mainly caused by a high number of participants from small consulting companies. If considered on their own, around 60% of the participants from the logistics services industry worked for large companies with more than 3000 employees and more than $ 500M in turnover.

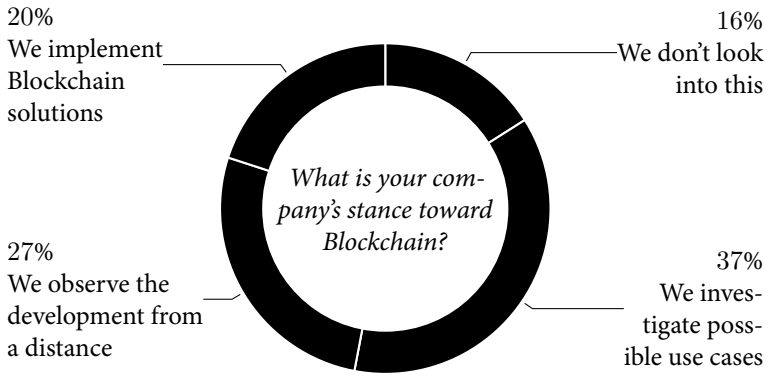


Figure 4.2: Companies' Stances toward Blockchain (n=151)

The participants' companies' experiences with Blockchain were also recorded. Figure 4.2 summarizes the results; 43% declared that they had not yet investigated Blockchain or only observed its development from a distance, while 37% investigated use cases and 20% had implemented first Blockchain solutions. As noted, this distribution was caused by consulting companies, as almost three-quarters had either investigated or implemented Blockchain solutions. Looking at the logistics service companies alone, around 65% said they were watching from a distance, if at all. Only two logistics companies had implemented Blockchain technology: one startup and one large logistics services company.

The four use case examples were introduced, presenting the information shown in Table 4.1 on page 63. The participants were to evaluate each case regarding (1) Blockchain's benefit and (2) the likelihood of adopting Blockchain. Table 4.2 on the facing page shows the findings for Blockchain's benefits through the mean values and standard deviations. On average, Blockchain was evaluated as offering considerable benefits for all use case examples. In all instances, the adoption likelihood (the mean values are shown in Table 4.3 on the next page) was lower but still likely.

However, the opinions were not uniform across the different participant groups: The mean values indicated that the middle managers were less optimistic, especially regarding adoption. An independent-samples Kruskal-Wallis test was conducted to assess whether the survey participants ratings' differed depending on their job level. In pairwise comparison, the use case examples' benefits ratings differed significantly between middle managers and chief officers for case 1 (Bonferroni

Table 4.2: Benefits of Blockchain

#	Example case	All participants	by job level		
			Domain experts	Middle managers	Chief officers
		(n=151)	(n=89)	(n=21)	(n=33)
1	Ease paperwork processing	5.70 ± 1.29	$5.66 \pm 1.21^{\ddagger}$	$5.10 \pm 1.48^{\ddagger}$	6.15 ± 1.32
2	Identify counterfeit products	5.09 ± 1.62	$4.84 \pm 1.62^{\ddagger}$	4.95 ± 1.35	5.67 ± 1.61
3	Facilitate origin tracking	5.27 ± 1.66	5.22 ± 1.67	4.81 ± 1.28	5.48 ± 1.92
4	Operate the IoT	5.70 ± 1.43	5.62 ± 1.47	5.76 ± 1.13	5.79 ± 1.53

‡ (significantly different from the chief officers at $p \leq 0.05$ level)

Table 4.3: Likelihood of Adopting Blockchain

#	Example case	All participants	by job level		
			Domain experts	Middle managers	Chief officers
		(n=151)	(n=89)	(n=21)	(n=33)
1	Ease paperwork processing	4.87 ± 1.48	$4.92 \pm 1.40^{\dagger}$	3.80 ± 1.20	$5.33 \pm 1.61^{\dagger}$
2	Identify counterfeit products	4.57 ± 1.54	4.49 ± 1.54	4.33 ± 1.35	5.06 ± 1.57
3	Facilitate origin tracking	4.46 ± 1.71	$4.59 \pm 1.72^{\dagger}$	3.66 ± 1.27	4.60 ± 1.93
4	Operate the IoT	5.21 ± 1.52	5.19 ± 1.65	5.09 ± 1.22	5.18 ± 1.44

† (significantly different from the middle managers at $p \leq 0.05$ level)

adjusted, $p \leq .005$, $n = 143$), and between domain experts and chief officers for cases 1 and 2 (Bonferroni adjusted, case 1: $p \leq .039$ $n = 143$ and case 2: $p \leq .014$ $n = 143$). Pairwise comparison for the use case examples' adoption likelihood ratings showed significant differences between middle managers and domain experts for cases 1 and 3 (Bonferroni adjusted, case 1: $p \leq .005$, $n = 143$, case 2: $p \leq .050$, $n = 143$) as well as between middle managers and chief officers for case 1 (Bonferroni adjusted, $p \leq .001$, $n = 143$).

Further, the participants that self-identified as more familiar with Blockchain gave significantly better benefits ratings for all use case examples than less familiar participants ($n = 151$ for all example use cases, case 1: $\tau_B = .326, p \leq .001$, case 2: $\tau_B = .186, p \leq .003$, case 3: $\tau_B = .173, p \leq .006$, case 4: $\tau_B = .202, p \leq .002$). The same held true for the adoption likelihoods for use case examples 1-3, but not 4 ($n = 151$ for all use case examples, case 1: $\tau_B = .264, p \leq .001$, case 2: $\tau_B = .181$, $p \leq .004$, case 3: $\tau_B = .154, p \leq .013$). Also, participants working in companies that had some understanding of Blockchain implemented solutions, investigated use cases, or observed Blockchain development gave significantly higher ratings for case 1 (use case example 1, $n = 151$: benefits: $\tau_C = .259, p \leq .001$, adoption likelihood: $\tau_C = .256, p \leq .001$). After an additional independent-samples Kruskal-Wallis test, a pairwise comparison revealed that the chief officers self-identified as more familiar with Blockchain than the domain experts and middle managers (Bonferroni adjusted, $p \leq .001$, $n = 143$).

In the next step, after evaluating the use cases, the participants gave their opinions about the primary beneficiaries of Blockchain applications in logistics. The findings are shown in Figure 4.3 on the facing page. Around three-quarters of the participants expect logistics service providers, senders, receivers, and technology providers to benefit.

The participants were also asked about likely barriers to Blockchain adoption in the logistics industry. Figure 4.4 on the next page summarizes the findings. For 56%, regulatory uncertainty may be a barrier. Around half also referred to the fact that different parties must join forces, a lack of technological maturity, and a lack of acceptance in the industry as major barriers. Data security concerns (41%), unclear benefits (40%), and an overdependence on Blockchain operators (28%) were further barriers.

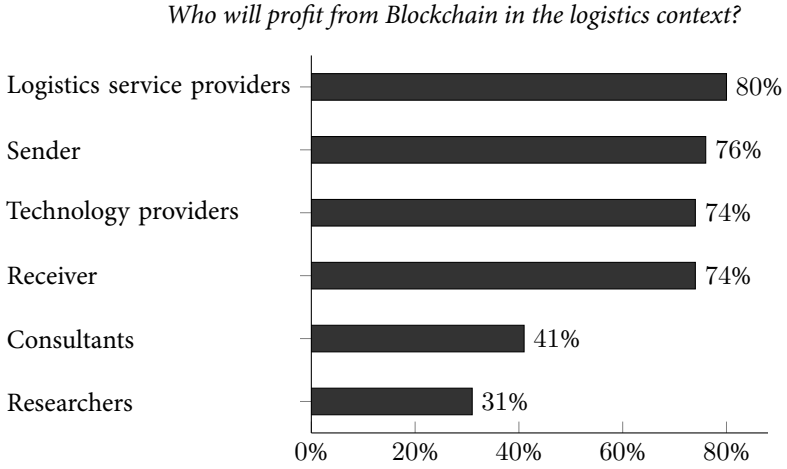


Figure 4.3: Beneficiaries of Blockchain – Percentage of Participants (n=151) That Expect These Companies to Benefit

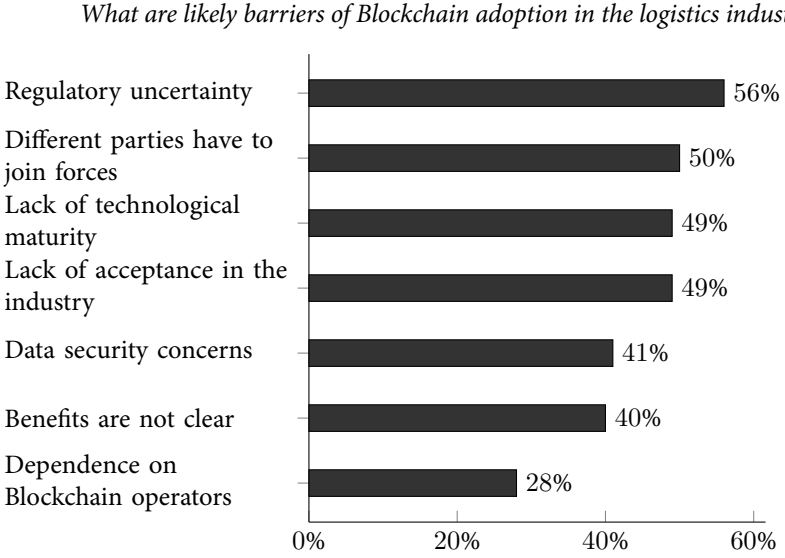


Figure 4.4: Barriers to Blockchain Adoption

For the beneficiaries and the barriers to adoption, no significant difference could be reported concerning the participants' hierarchical level or sector. However, participants' familiarity with Blockchain positively correlated with the beneficiary sender ($r = .217, n = 151, p \leq .007$). Participants' familiarity also positively correlated with the barriers to adoption of regulatory uncertainty ($r = .183, n = 151, p \leq .025$) and having to join forces with other parties ($r = .219, n = 151, p \leq .007$).

Finally, the participants evaluated Blockchain's overall effects on processes and business models in logistics. On a 10-point Likert-scale (ranging from "Blockchain will barely affect them" to "Blockchain will radically transform them,"), the average evaluation was 7.08 ± 1.88. Thus, the participants believed that Blockchain would substantially affect the industry, even though the transformation may not be as radical as some trade press articles have heralded. The size of the standard deviation (1.88) proved that there were both skeptics and enthusiasts. A Kruskal-Wallis test revealed that companies with Blockchain experience that have already implemented Blockchain solutions gave significantly higher ratings than those that are only observing or have not looked into Blockchain (for both pairs: Bonferroni adjusted, $p \leq .001$). Further, familiarity with Blockchain significantly correlated with a higher rating on the overall effect ($\tau_B = .291, p \leq .001$). However, no significant differences could be found concerning the participants' hierarchical level or sector.

4.3 Discussion

The study revealed valuable insights about Blockchain adoption in the SC&L context. Despite realizing the impacts Blockchain may have on their industry, companies seem hesitant to dedicate resources to investigate possible Blockchain applications. Most of the presented use case examples were considered beneficial and likely to be adopted. Blockchain was considered to benefit virtually everyone along the supply chain: logisticians, senders, and receivers, and technology providers. Yet, almost half of the participants' companies had not yet worked with Blockchain.

One reason may be the different perspectives of the participant groups. If the participants' hierarchical level is considered, the data suggests that the experts from middle management are less optimistic about Blockchain than the chief officers or domain experts. Their ratings were lower on average and significantly on Blockchain

adoption likelihood for the cases *ease of paperwork processing* and *facilitation of origin tracking*. This observation could also be made for the barriers: For instance, 57% of the middle managers raised data security concerncs, while only 27% of chief officers shared this reservation. On the one hand, this lack of enthusiasm could lie in the middle managers' better overview over their processes. Since they are likely responsible for implementing new IT solutions (at least from the business perspective), they may consider Blockchain to be overhyped and as just another IT development thought to be the silver bullet. On the other hand, the chief officers self-identified as being more familiar with Blockchain and therefore may have better insights.

The Blockchain experience level was also a general differentiator. The data suggested that the more familiar participants are with Blockchain technology or the more experience their companies had (e.g., exploring use cases instead of just observing Blockchain's development in the industry), the more positively they evaluated Blockchain. Steadily growing ratings of benefits and adoption likelihood were found across all four experience levels. However, their perspective on the possible barriers to adoption shifted: While only one-fourth of the inexperienced participants expected collaboration with different partners to be a barrier, around 59% of participants with implementation experience indicated that a high level of collaboration and commitment may be a barrier. Also, the participants who were more familiar with Blockchain considered regulatory problems a much bigger problem than the inexperienced ones.

4.4 Preliminary Conclusions

This study was a broad first investigation of the perceived potentials of Blockchain solutions for SC&L. The results also illustrate companies' strong interest and hold implications for research and management practice. However, some limitations must be kept in mind when interpreting the results. In Chapter 6 on page 153, the findings will be integrated with the results from Chapter 3 on page 21 and Chapter 5 on page 79.

4.4.1 Implications for Research

Besides the interest, the results also showed considerable skepticism only – 20% of the companies in the sample had worked with a Blockchain solution. There is very little public documentation of these practical endeavors; it remains an open question how many of them were successful or completed. On the other hand, this lack of data and knowledge provide extensive research opportunities regarding Blockchain in SC&L.

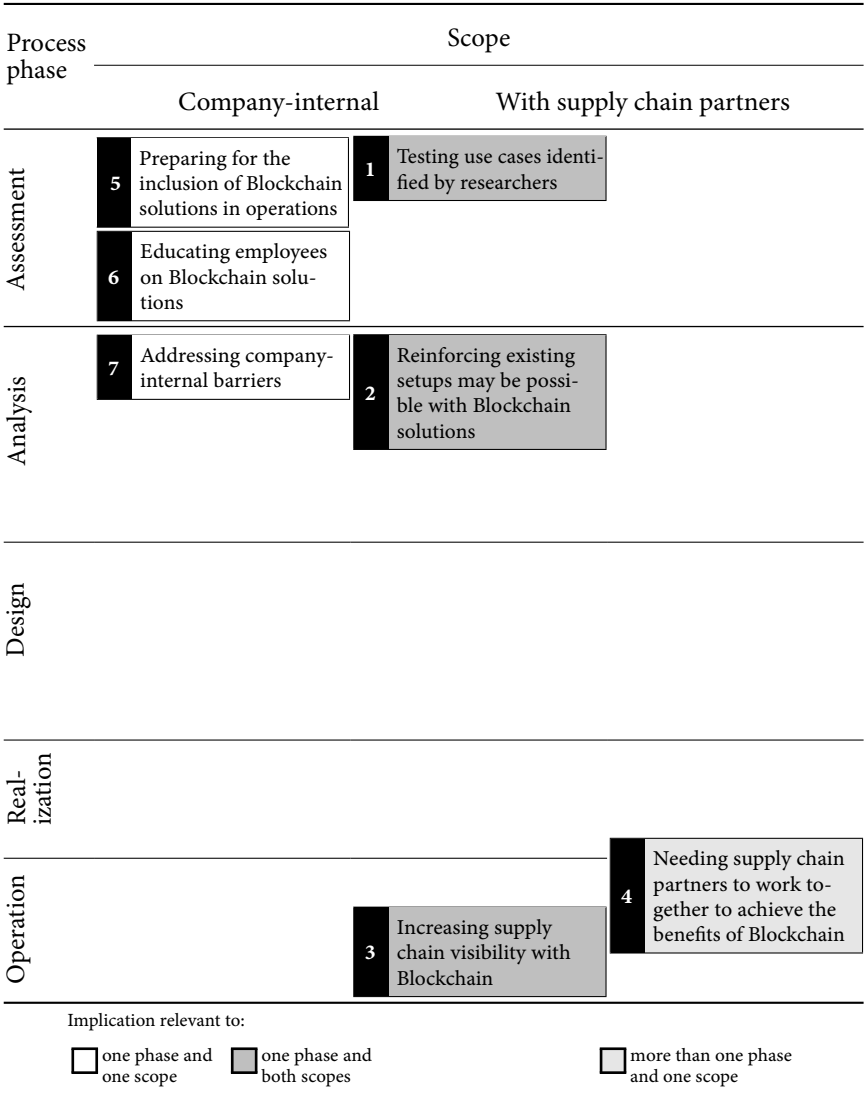
Qualitative studies will be required to gather this knowledge. To develop concepts that apply in practice, it will be crucial to understand how companies approach Blockchain solutions and how they handle the barriers outlined in the results section. Further, the sample use cases mainly depend on practitioner reports. Research must progress toward outlining new use cases for Blockchain in SC&L beyond meta-level descriptions of possibilities. More specifically described use cases can then also help SMEs with limited research capacity.

Quantitative studies that focused more on specific changes in SC&L could help identify especially promising use cases and the magnitude of change they may bring to SC&L processes. Clearly identified indicators that influence the Blockchain use could boost the further development of industry solutions. Such indicators could be identified by testing managers' technology acceptance and behavioral intentions. An additional contribution could be to identify more detailed factors that led to the outlined differences between employees on different hierarchical levels.

4.4.2 Implications for Management

The study allows for the derivation three key implications for company managers: First, while it will likely be a long process, the first implication is that the use of Blockchain solutions in SC&L can be expected in the future. The replies indicated likely adoption and possible benefits of the four exemplary use cases and most participants in a supply chain using Blockchain. Thus, companies should prepare for the inclusion of Blockchain solutions in their daily operations (5 in Table 4.4 on the next page).

Table 4.4: Embedding the Implications (1-7) for Management in a Process Model for Business Integration by Nedbal (2013) (cont. from Table 3.15 on page 57).



Second, as illustrated in the discussion, survey participants who self-identified as more familiar with Blockchain or more experienced were more positive toward Blockchain and noted its revolutionary character. However, they also emphasized some barriers to adoption that less experienced companies did not recognize. These participants can likely evaluate Blockchain's benefits better. Companies should educate selected employees to make substantiated decisions regarding Blockchain solutions (6 in Table 4.4 on the preceding page).

Third, companies should familiarize themselves with the barriers outlined in the results sections and the extent to which these apply to them. Most of the external barriers, such as regulatory or technological questions, will likely be solved in the next years. By this time, the companies should have solved the possible internal barriers, such as joining forces with other companies or addressing data security questions (7 in Table 4.4 on the previous page).

4.4.3 Limitations and Opportunities for Further Research

The interpretation of the outlined results must consider some study limitations. Notably, the Blockchain sector is evolving rapidly. Participation in new Blockchain projects are continually announced by various companies, albeit not always with the intent to implement a Blockchain solution after all. Thus, the evaluation even of the use case examples may change as learnings from these new projects diffuse through the industry. The study considered only four use cases so as to keep the survey focused on the major ones and within a reasonable response timeframe for the participants. Thus, limited generalizations can be drawn from the use case examples.

Since about half of the participants were from Germany, the answers lean toward the situation in Germany. While this inclination is somewhat mitigated by the fact that the tested use case examples are applicable worldwide, countries that depend less on exporting or are less digitally connected may consider Blockchain technology to be less promising. Further, there were many consulting companies in the sample; these have a sales intention and often do not have to work with the resulting solutions, making them more favorable toward new technology solutions. While during the recruitment, expert communities were addressed, Blockchain experience was self-assessed and was geared toward knowing the technology rather than investigating the extent of the knowledge. This approach was chosen because

no broad, long-term knowledge of industry experts was to be expected. After all, no long-term cases had existed at the time of the survey.

A future study can control for these limitations as Blockchain becomes more widely used. On the one hand, more established and a wider array of cases can be selected. On the other hand, additional questions to measure experience with Blockchain applications for SC&L in more detail could be introduced. Further, as discussed, the consulting companies' answers strongly influenced the sample. It can be expected that, in the future, more experts from SC&L can be recruited; thus, researchers should look closely at logistics and differences among the various logistics functions.

Further investigation is required into why the companies have decided to not work with Blockchain and which measures would persuade them to do so. Additional qualitative research into the identified barriers but also possible additional barriers could bring this to light. Further, the results showed that the middle managers were less optimistic about implementing Blockchain solutions in SC&L. The reasons for their reservations should be captured in future studies to derive advice for coming Blockchain solutions.

Overall, this study has shown that Blockchain solutions provide potentials for SC&L, despite existing barriers. Practitioners with first insights into Blockchain expect extensive benefits for logistics companies and along the whole supply chain. At the company leadership level, the adoption of Blockchain solutions is considered likely. Chapter 5 on page 79 provides an in-depth look into at the paths companies can take toward adopting Blockchain solutions in SC&L.

Chapter 5

Exploring Blockchain Adoption in Supply Chain Management and Logistics Practice

Blockchain could be a game-changer for the information exchange in SC&L, providing the tightly integrated information flow that companies dream of realizing (Kersten et al. 2017). Well-executed information flows could help improve efficiency and reactions to disruptions, and could possibly be a key enabler for closed-loop supply chains (Jabbar et al. 2018; Casino et al. 2019; Govindan et al. 2015). As established in Chapter 4 on page 61, huge expectations regarding the benefits of using Blockchain in SC&L exist in the industry. Likewise, as shown in Chapter 3 on page 21, a considerable number of studies outlined how Blockchain could be useful for SC&L.

However, most authors have focused on establishing the *what,* (i.e., concepts, application opportunities) and the *why,* (i.e., possible benefits) rather than the *how,* (i.e., adoption processes). Further, while, in the previous chapters, possible reasons for the use and exemplary barriers were described the implications for the adoption process for Blockchain for SC&L in companies remain unclear. Investigating the contingencies and approaches of Blockchain adoption is considered an important field for further inquiry (Casino et al. 2019; Wang et al. 2018; Queiroz et al. 2019a). In this chapter, the following research question is addressed:

RQ3: How do companies adopt Blockchain in SC&L?

Because there are many facets to the adoption approach, this research question is further specified by three questions that address individual aspects:

RQ3a: How have companies familiarized themselves with Blockchain adoption in SC&L?

RQ3b: Which factors are preventing companies from adopting Blockchain in SC&L?

RQ3c: Which conclusions do companies draw from the first adoption steps?

These questions are addressed with an exploratory Grounded Theory methodology to contribute to the understanding of companies' approaches to *Blockchain in SC&L*.

The remainder of the chapter is structured as follows: Next, the methodology is introduced and the sample is described. The results are then shown: approaches, barriers, and learnings identified during the interviews are presented and discussed in-depth. The chapter concludes with a description of possible implications for research and practice, study limitations, and possible opportunities for further research.

5.1 Method

An explorative, qualitative Grounded Theory approach was chosen to investigate how companies approach Blockchain in SC&L. The application of Grounded Theory is feasible whenever "researchers have an interesting phenomenon without explanation and from which they seek to discover theory from data" (Suddaby 2006). In the case of Blockchain in SC&L, the previous chapters outlined the lack of studies that explain the phenomenon.

Grounded Theory is a systematic way for methods and practices to gather and analyze qualitative data and "to construct theories *grounded* in the data themselves" (Charmaz 2014, p. 2). Charmaz (2014, p. 10) also illustrated how this set of practices allows or the development of an "interpretive portrayal of the studied world," which is the intention of this study, with the goal to answer the research questions.

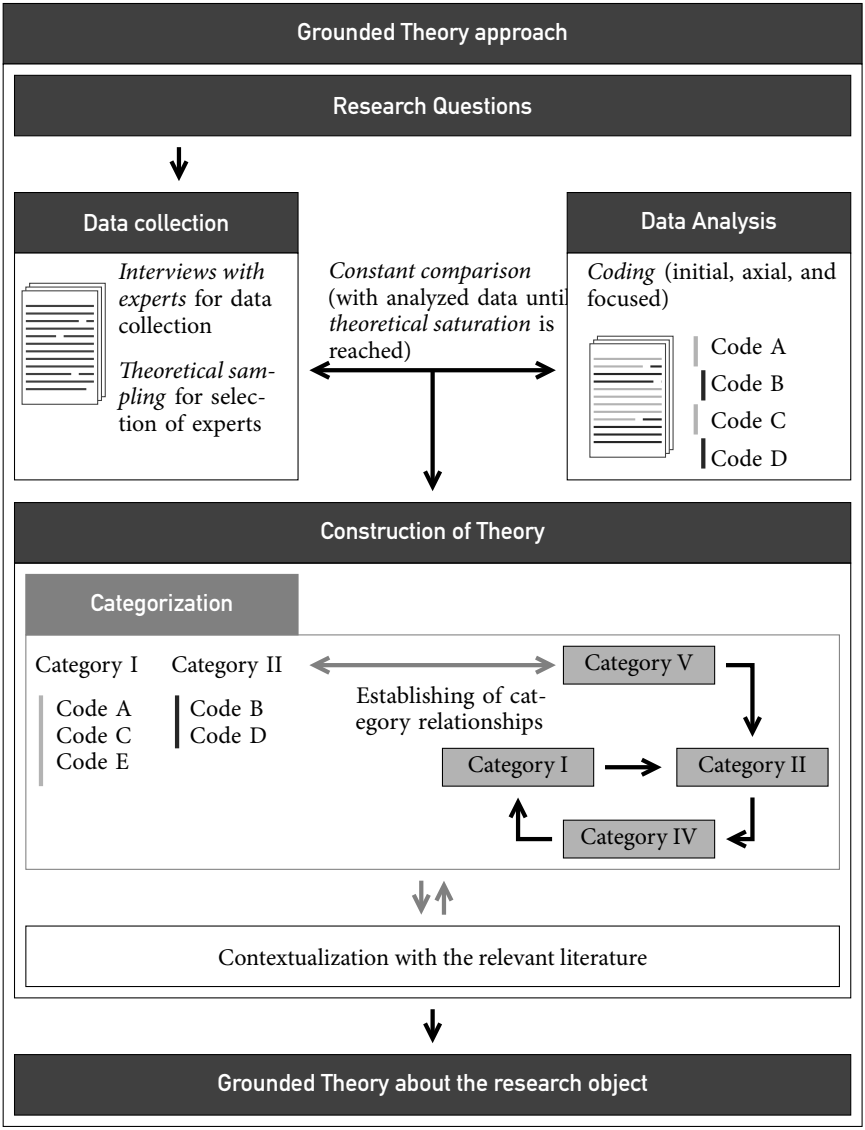


Figure 5.1: Research Process of Constructing Grounded Theory (illustration based on Petersen et al. (2016))

Figure 5.1 on the previous page contains an overview over each step in the research process and how the theory was constructed from the data. The activities are presented linearly, even though the research process was characterized by iterative phases of sampling, data collection, and analysis. Throughout the research process, measures were taken to ensure the research process' validity and the quality of the findings as proposed by Strübing (2008, pp. 92–94), da Silva Barreto et al. (2018), and Flint et al. (2002).

Between June 2017 and January 2019, the collection of the qualitative data took place through 24 semi-structured interviews, which lasted between 21 and 118 minutes (mean: 59 minutes, median: 56 minutes), were conducted in person (10/24) or telephonically (14/24), in either German[c] (14/24) or English (10/24). In keeping with a theoretical sampling approach, three industry experts with broad knowledge of the SC&L sector were recruited as an initial sample (Charmaz 2014, pp. 100–108). The recruiting of the experts followed the emergent topics and categories. Appendix D on page 198 contains the full sample of the experts in chronological order. All interviewees had at least one year of relevant Blockchain experience and were preferably involved in a Blockchain initiative in their organization. In two cases, early participants were invited back to discuss specific aspects that surfaced only after their initial interviews.

The full interview guideline had three parts with open questions. This semi-structured approach allowed for open discussion of the relevant topics while still touching on the points of investigation. The interviews started with a short introduction to the experts' first encounters with Blockchain. After that, it was discussed how the company is currently applying Blockchain solutions, and how the companies made business decisions regarding Blockchain (e.g., "How are companies deciding to use Blockchain?," "How are companies going about implementing Blockchain strategically?"). In part 3, the experts were asked about Blockchain's overall implications for SC&L operations (e.g., "How has Blockchain affected the SC&L industry overall?"). The questionnaire was adapted slightly, in keeping with Charmaz (2014, p. 11), to address aspects slightly uncovered during the interviews. The final interview guideline was used from interview 7 onward and can be found in Appendix C on page 196.

The respondents' experience was classified post-interview, ranging from medium (respondents investigating use cases), to high (respondents who were been part of

c The quotes presented from interviews conducted in German were translated by the author for presentation in the results section.

a proof of concept (PoC)), to very high (respondents using Blockchain as part of their core business or conducting extensive Blockchain projects).

The interviews were transcribed and coded in parallel. The coding process followed the principles of Grounded Theory coding of Strauss and Corbin, as outlined by Charmaz (2014, pp. 46–66), yielding 1022 codes during the initial coding cycle. Alongside the initial codes, short memos were written to keep track of identified relationships and support the analysis. After initial coding, the codes were grouped into categories during a focused coding phase. In step 3, this process yielded four axial categories that allow for conceptualized reasons to adopt Blockchain in SC&L, paths, and barriers to doing so, and learnings gathered during this adoption process.

Data collection was concluded after 24 interviews. The last four interviews provided no additional insights, but instead confirmed the existing properties of the categories and the understanding therein. They therefore satisfied the criteria of the Grounded Theorists Strauss and Corbin, as outlined by Charmaz (2014, pp. 103–105).

Further, as an extension of the model characteristics, a typology was formed. Typologies allow a deeper understanding of a phenomenon and expose its features (Kluge 2000; Promberger 2011). The characteristics for deriving the types stem from the code families and categories derived through the application of Grounded Theory, and help to gain a better understanding of the Blockchain adoption paths that companies are taking (Fleiß 2010; Petersen 2017, p. 67).

5.2 Results and Discussion

In this section, the different approaches to Blockchain in SC&L, as well as barriers to and reasons therein, are presented. Partial or preliminary results have been published as an online, open-access paper in IEEE Access and presented at the R&D Management conference in Paris, 17-21 June 2019. This study covers the full results set and shows the interrelationships between the different categories, allowing for the derivation of a comprehensive set of observations.

The analysis' results are presented analogously to Figure 5.2 on the facing page, where the relationships between the categories are depicted. Notably, the figure already shows an outcome and was not developed before the analysis. As a first step, a typology is introduced, representing three ideal company types engaging with Blockchain: *hypsters, endeavorists,* and *enthusiasts*. Each company type has its own profile, ranging from little engagement to deep-diving into Blockchain technology.

Two adoption paths were found during the analysis: The first, the *organizational path*, has three parts – each is a way in which companies have adopted Blockchain in their organization: (1) the establishment of an organizational construct to create an entity that (2) can provide governance and (3) can establish cross-industry market power. The second, the *practical path*, is exclusive to *endeavorists* and *enthusiasts*. These company types have tested or trialed first Blockchain solutions in practice and are taking first steps in designing business models that can create thriving ecosystems for supply chains.

The progress of the companies on both adoption paths is eventually influenced or stopped by external and internal barriers. Solving the discovered external barriers is hardly possible for single companies by themselves; most of these barriers relate to limitations of the technology, except those concerning regulatory matters. However, single companies can solve the internal barriers; these are mostly related to strategic and operative decisions that these companies are hesitant to take.

The analysis also revealed companies' learnings from their efforts to adopt Blockchain solutions and, thus, discovered barriers. They partially extend the barriers but also serve as an input when these companies approach the adoption of Blockchain solutions again.

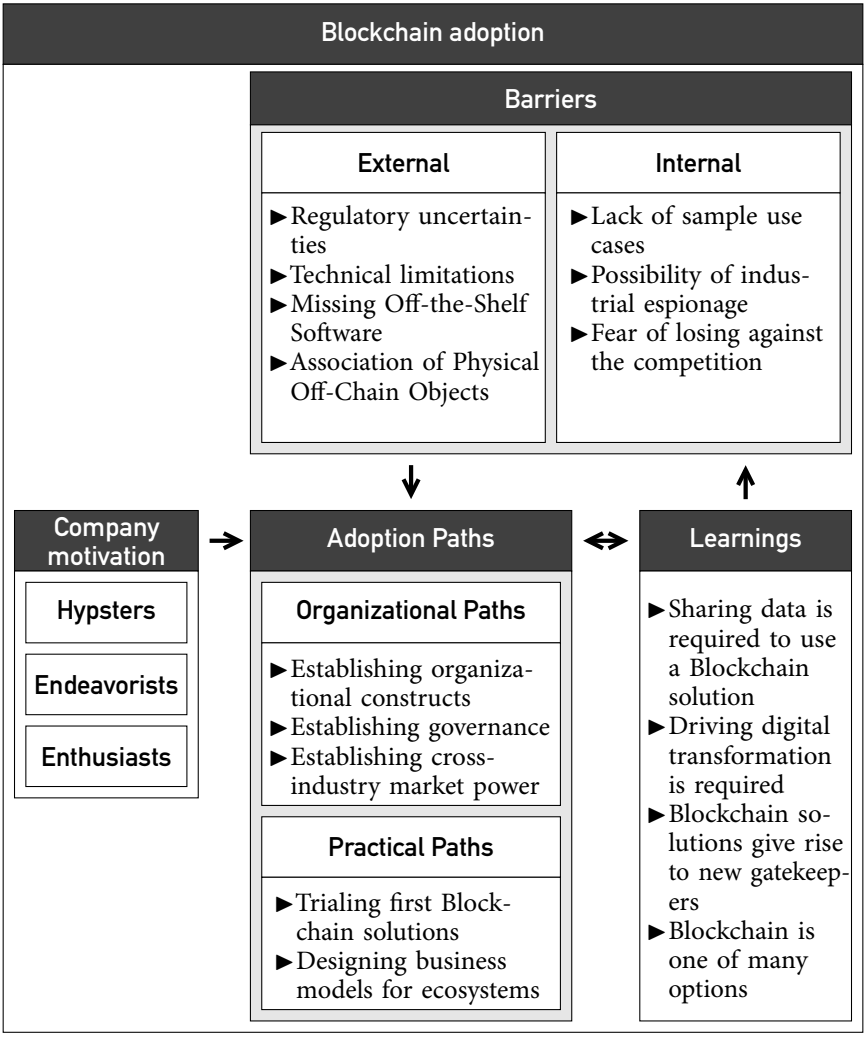


Figure 5.2: Blockchain Adoption in SC&L: Company Types, Paths, Barriers, Learnings and Their Relationships

5.2.1 Motivation: A Company Typology

The gathered data allow considerable insights into the reasons for companies to enter the Blockchain space. It is a move that is driven not only by a fear of missing out induced hype and hope for innovation marketing stunts, but also an honest, partly critical interest in the possibilities Blockchain may deliver for the companies and their products. These reasons emerged as five categories in the data:

1) Hype – Companies are considering Blockchain owing to the news and magazine reports around possible Blockchain use cases, along with the explosion of the Bitcoin's price. This hype induces a fear of missing out on new industry developments, on the one hand, with industry executives trying to somehow get into the Blockchain space on the other.
2) Marketing – The spotlight on Blockchain applications in practice is used by these companies to promote their products or services.
3) Efficiency gains – Companies are hoping to realize more efficient supply chains and logistics services by applying Blockchain technology. These companies are researching better data structuring, automation, the replacement of third parties, and supply chain-wide tracking and tracing.
4) Infrastructural benefits – Blockchain technology can be beneficial for IT infrastructure providing, for instance, large networks, or to reduce risks in local IT setups.
5) Enabling new services – Companies are planning to use Blockchain to provide new services, features, and functionality that would otherwise be costly.

A typology of three ideal types is derived from the five outlined categories, as shown in Table 5.1 on the next page. The derived types for this study are ideal ones – examples that fully fit one type – as well as hybrids of several types exist in practice. All three types will now be introduced, extending the reasons and revisited when considering adoption paths, barriers, and learnings.

5.2.1.1 Hypsters

This word combines *hype* and *hipster*. On the one hand, it borrows from the discussion around the social cliché of the hipster, who is often considered pretentious and

Table 5.1: Typology of Ideal Company Types

Categories	Hypsters	Endeavorists	Enthusiasts
Hype	✗		
Marketing	✗		
Efficiency gains		✗	✗
Infrastructural benefits		✗	✗
Enabling new services			✗

inauthentic (Greif 2014, p. 31; Baumgardner 2014, p. 81). The intention to move toward Blockchain mainly as a marketing vehicle reflects this inauthenticity. On the other hand, the draws on hype as the primary driver to enter the Blockchain space. An expert from this company type explained:

> *You hear that word everywhere. Especially in the area of supply chain and logistics, it [Blockchain] has broken away from Bitcoin and has also migrated to the other areas.*
>
> *expert #17, logistics service provider*

Many of the experts noted that there is huge interest in Blockchain. The resulting pressure leads to companies claiming they are planning to apply Blockchain despite the lack of a working use case or a fit to their processes. An expert stated:

> *Blockchain is a hype. It gets a huge interest, but what I also see - for the moment, it is a little bit overhyped. People start using Blockchain or say that they will use Blockchain for everything. After the hype, we will have a period where people will get back down to earth.*
>
> *expert #1, IT solutions provider*

Another expert mentioned that a motivating reason is a fear of missing out on a widely discussed topic:

> *One aspect is undoubtedly the fear of missing out. You have to deal with Blockchain. The big companies have pressure, and disruption is a heavily used term. However, disruption is also associated with Blockchain.*
>
> *expert #4, consulting company*

This rush is also fueled by reports of large companies working on this technology, as multiple experts pointed out. An expert noted:

> *If the big shipping companies and other logistics heavyweights participate, then the big companies can also exert pressure.*
>
> *expert #3, IT solutions provider*

One idea is that early innovators or corporates later pressure *clueless* companies into using their solution, as the experts pointed out, and as demonstrated for instance by the retail giant Walmart. Walmart asked all its fresh leafy greens suppliers to form part of its proprietary, private, end-to-end Blockchain-based tracking solution within a 12-month notice period, making it hard for them to build their own solution (Corkery et al. 2018; Walmart Inc. 2018). However, the experts also noted that technology providers and consulting firms with sales intentions are often the driving force for these companies.

However, sales and marketing intentions are also valid for companies. The following statement illustrates the premises under which *hypsters* enter the Blockchain space:

> *[…] At the moment, you get a lot of attention when you say: "We do this with Blockchain." Then you can make topics that otherwise may not trigger so much interest a bit more interesting.*
>
> *expert #2, consulting company*

In reality, using Blockchain technology is not necessarily the intention, but mentioning it makes for a good sales spiel. The hype also allows one to use changes previously irrelevant to outsiders as an advertisement of innovativeness. A change in an internal process at KLM Royal Dutch Airlines is an example here: News reports are now discussing the optimization of an intra-airline payment process as an achievement because its innovation unit uses a Blockchain solution (Cocco 2018; Kastelein 2020). The experts also noted this:

> *I mean, mainly, lots of resources are burnt because people just want to try it out, and then make a press release.*
>
> *expert #22, IT solutions provider*

Proactive positioning in a potential market and the advertisement part stand out here. The experts stated that it can be hard for companies to be front-runners everywhere and that companies must present this added value well, even if they don't go forward with any solution:

> *[…] you want to position yourself in the market somehow beforehand so that you can run more marketing campaigns if you do some things yourself. This is a bit of early adopter story: We have to ensure that we sell it as added value and that the customers feel that we are really establishing ourselves there and not two months later that someone can take it away from us.*
>
> *expert #17, logistics service provider*

In short, two main characteristics fuel *hypsters*' motivation to enter the Blockchain space: First, the immense hype around Blockchain and an induced fear of missing out or being left behind; second, using the spotlight on every Blockchain announcement as a vehicle for their company's innovation marketing activities. For *hypster,* technological or practical possibilities of Blockchain technology are of little concern.

5.2.1.2 Endeavorists

The endeavor of entering the Blockchain space is a much more serious undertaking for this company type. The hype has its customers asking about or bringing Blockchain to their attention, and some do see the marketing possibilities. However, these aspects are not crucial for *endeavorists*. Their main interest is the technology's capabilities – efficiency gains or IT infrastructural advantages – rather than possible advertisement uses.

Naturally, companies plan to improve their overall SC&L efficiency by using Blockchain to improve an underlying process. The experts identified four approaches to how implementing a Blockchain solution may help realize these improvements.

According to the experts, Blockchain could help by: (1) improving overall data quality, (2) automating processes, (3) replacing third parties, and (4) enabling supply chain-wide transparency and tracing.

Improved data quality can drive efficiency gains, since many downstream processes depend on availability, structuredness, and accessibility of data. If the data are on the Blockchain, all these criteria are fulfillable: Blockchain is decentralized, transactions are checked before being accepted, and the data structures are accessible by all participants. The experts noted this as a substantial improvement regarding the structure of data, as well as processing and availability:

> *When everyone types their data into these data fields, then it is already standardized.*
>
> *expert #5, bank*

> *We still have classic file processing. Files come in; they have to be interpreted; they have to be associated; they have to be read. Suppose I get the data delivered via Blockchain using standard replication. In that case, I don't have to worry about the EDI paths, the data are always available to me, and I can read and write locally. And this is the big advantage we see at this point.*
>
> *expert #19, logistics service provider*

According to expert #19, the structured availability of data on a shared platform will allow automation through company IT systems or directly on the Blockchain through smart contracts. The experts thought of possibilities such as automation of negotiation and settlements for standardized logistics services, but also automated actions depending on status reporting throughout logistics processes or ensuring the completeness of freight documents, possibly eliminating their manual handover:

> *You have a lot of manual processes in the supply chain, and if you look at them, they are often if-then conditions. When the goods arrive in the port, please release the numbers. You can automate this with the help of smart contracts.*
>
> *expert #5, bank*

> *Some startups digitalize such documents with photos and checklists, hugely accelerating such [compliance] processes. Here, the next step would also be a Blockchain to secure compliance: If you can now process such photographed documents, check them against certain criteria with the help of algorithms, you may be able to trigger escrows with smart contracts and make direct payments.*
>
> *expert #3, IT solutions provider*

Further, regarding improving efficiency, the experts affirmed that SC&L historically has many intermediary parties, which serve the purpose of consolidating upstream branches of the supply chain to reduce complexity and provide one trusted entity for negotiations. Some experts suggested that Blockchain could provide this trust and could virtually eliminate the extra steps introduced by these intermediaries, possibly improving overall efficiency and reducing costs. This way, in some supply chains, Blockchain may increase visibility and provide business opportunities to companies that previously had to rely on intermediaries. The option to reduce the dependency on third parties was especially stressed by experts with a high IT affinity, for instance:

> *People don't particularly want a trusted third party. […] In supply chain, for instance, people don't want a single company owning the whole supply chain system. […] They would like to have a system where companies can work together collaboratively and not necessarily trust one another, but can still work together, and that is what Blockchain really brings.*
>
> *expert #9, IT solutions provider*

It became clear that the replacement of intermediaries will be limited to those that provide no additional added value, for instance, services for data transformation or platform-like marketplaces serving as gatekeepers. Intermediaries or third parties who provide specialized services, securities for assets, or physical infrastructures are expected to remain necessary. An interviewee stated:

> *In logistics, if it's just about arranging highly standardized transports, [removing the intermediaries] could be the case. When it comes to more specific things, such as transport outside the EU or hazardous substances or customs regulations, there is probably still a long way to go to automating this.*
>
> *expert #2, consulting company*

In marketplace-type platforms, transactions can be conducted directly between the involved parties; even machines can join the trade:

> *[…] a truly decentralized transaction platform, where a good finds the transport on its own, and looks at local markets: How do I get from A to B to C, for example? The combination with autonomous trucks, drones, and all that stuff, these are machine-to-machine transactions that converge at that point.*
>
> *expert #10, electric utility company*

The decentral setup in Blockchain allows all participants to be involved in transactions and sets up visibility, matching their needs. According to the experts, this transparency is creating the trust companies need in order to for instance set up trades.

The fourth reason for expected efficiency gains is the increase in supply chain-wide visibility and transparency through tracing and tracking. Physically attached individual identifiers can be associated with the products, and the handling entities can then sign for each step on a shared Blockchain. Overall, this will provide an improved data basis for corrective actions and the optimization of processes.

Further, the data stored on the Blockchain also provide a basis for auditing and a documentation trail for products or parts. Because tamper resistance and accountability are requirements of audit trails, experts expect this to be one of the first use cases. The possibility to backtrack in an audit may have to go beyond the company's reach, making a decentralized system ideal. A few experts found that Blockchain could be a solution for this:

> *For example, aircraft spare parts: these objects are very valuable, peoples' lives depend on them, they change custody, and they change status as well. So, when they go from one hand to another hand, it could be that they are repaired or that they are used. The status changes as they change custody.*
>
> *expert #15, international trade association*

> *When it comes to raw materials, for example, we want to be sure to know where the raw materials come from, so we know they really are the components or raw materials that we ordered or commissioned.*
>
> *expert #16, manufacturer*

However, some experts doubt the usefulness of exposing this information to other companies:

> *In a normal situation, this traceability would not be granted to the outside world, because it provides no value there.*
>
> *expert #7, manufacturer*

In contrast, the analysis of a supply chain's overall performance may require exactly these data. Some experts acknowledged this:

> *If I don't share my data that comes in, I can take my process to the optimum. […] Then the downstream process at another company that follows this cannot do that.*
>
> *expert #17, logistics service provider*

> *We hope that Blockchain technology will enable us to know much more precisely which container goes where in the Hinterland, where they come from, where they are transported to, and what the intention behind it is. Because this is interesting for us in terms of traffic optimization, traffic planning, and traffic management.*
>
> *expert #6, authority*

> *I mean, you solve things that are visible. If certain things are not visible, they are not going to get the necessary attention. If you have a Blockchain where everything is recorded, and there is absolutely no way of getting out of that, then it is going to be a lot easier to find issues and actually attack them.*
>
> *expert #18, manufacturer*

Blockchain's technological basis makes using it attractive in the SC&L IT infrastructure, namely the possibilities to (1) lever a large network infrastructure and (2) benefit from data loss risk reduction in the network.

Companies can build Blockchain applications that are scalable and swiftly deployable. There are few upfront costs compared to a centralized infrastructure. Further, the infrastructure is typically owned by its users, reducing dependencies on central parties. Cloud setups have technological advantages but require centralized administration (Zohar 2019). An expert explained how this makes the solution more independent:

> *Yes, well, we do not build any infrastructure ourselves; we see ourselves more as integrators, as users [of a Blockchain]. […] We set it up and use what is available, preferably what is new on the one hand, on the other hand, already as mature as possible.*
>
> *expert #13, logistics service provider*

The use of Blockchain as an infrastructure solution also bears the possibility to reduce the risks of possible data loss by sharing the transactions among many participants. The data cannot be tampered with and can be restored from the network. The availability of historical data is useful for following up on business processes later on, and some experts hope to outsource this on the Blockchain:

> *The complaint comes in three months, four months, five months later, or even much later. This means we start looking through ancient data, and [it is so much that] you can no longer put them on hard disks. So, this means they are written into archive systems, on DVD, God knows, which is an incredible effort. If we were able to get this data off the Blockchain, our entire organization of the entire EDI traffic would be much easier.*
>
> *expert #19, logistics service provider*

However, it is also considered useful to secure communications between supply chain actors or with IoT devices (e.g., sensors) along the supply chain; data points and transactions can be signed using the known key-pairs.

Overall, *endeavorists* see possibilities and are eager to move into the Blockchain space in order to utilize the features set this technology can provide. An expert stated:

> *We are not a technology company. We are a company that tries to make money by handling containers. If [Blockchain] helps us do this, we will do it, and if it does not help us, we will not do it.*
>
> *expert #19, logistics service provider*

This quote also illustrates the differences to the *hypster* (see Section 5.2.1.1 on page 86): *Endeavorists* have high expectations, but the focus is on unlocking additional potentials by including technical abilities into existing SC&L processes.

5.2.1.3 Enthusiasts

The *enthusiast* is the company type that is most convinced by Blockchain. Unlike *endeavorists, enthusiasts* are sure of the outlined features and plan to offer solutions or services using Blockchain technology. While they arguably benefit from the high interest surrounding Blockchain and likely use this as a vehicle, advertising is not their focus, and neither are the possible technological limitations.

The following extracts from two interviews underline this illustration. In this first case, the interviewer had proposed that some companies find it a burden to set up Blockchain implementation, to which this expert quickly replied:

> *It is absolutely not a burden: We can deploy these things within a month. We keep things very simple.*
>
> *expert #20, logistics service provider*

In the second case, the interviewee noted that the discussion of Blockchain's limitations are on a fairly high level compared its customers' current alternative, which is to "just e-mail the PDF" (expert #23, IT solutions provider).

However, the improvement in applications is not the real difference between *enthusiasts* and *endeavorists.* After all, the *endeavorists* could – and do – invest, moving

forward, building Blockchain applications. *Enthusiasts* focus more on the value of the network, and the value applications using it could create by enabling other products:

> *There are a lot of people who all of a sudden think they can build a business on the back of the Blockchain by using the old model of "there is a trusted organization in the middle which you have to pay a fee to."*
>
> *expert #9, IT solutions provider*

Beyond *Endavorists*' ideas, some *enthusiasts* also used Blockchain to provide services and enable features in new products. Multiple experts noted that Blockchain could provide the basis for digital identity services, or enable schemes for sharing and access in additive manufacturing, IoT devices, or autonomous vehicles.

> *Blockchain itself will not fully disrupt supply chains. It is going to be combined with the other big trends of supply chains such as big data, cloud, artificial intelligence, IoT, and things like that.*
>
> *expert #20, logistics service provider*

The basic idea of Blockchain-based digital identities is that the transaction history, identifying properties, or affirmations signed by third parties are attached to an entity's key-pair, effectively creating a multifaceted identity (da Silva Barreto et al. 2018; Liu et al. 2020). There have been extensive additional discussions regarding the design and the management of these self-sovereign identities, illustrateing the topic's importance beyond SC&L (Liu et al. 2020; Haber et al. 2020; Patole et al. 2020).

These properties are not limited to people's identities. It is possible to extend them to any objects, such as containers, pallets, or vehicles. In turn, an assignment of approvals, clearances, or even funds to any of these objects becomes possible. Companies can use this to offer new attestation services, but also provide new features for their devices and machines. Blockchain-enabled machines could connect to a global marketplace for instance for spare parts, to sell their capacities or buy production licenses. Sensors could share their data across different entities; they could also sell it and directly transfer the payment into their machine wallet.

In SC&L, a major benefit could be that identities could be associated with each handling step. Also, the experts see a benefit in the possibility of digital signatures

and attestations. The acceptance of signed transactions could be equal to the signing of documents, clearances, or other approvals. Digital identities are also a building block for empowering small actors in supply chains by giving them visibility and eventually allowing for the bypassing of third-party intermediaries. An expert noted:

> *[…] in agriculture, if you go below a certain level, those suppliers are not visible, and because they are not visible, they have a very poor place strategically in the supply chain and economically. But if you provide them with some kind of identity and therefore, with that identity also, they can have a performance history. They will also be better able to negotiate prices and prove what they are doing, and that will probably cut out some of the middlemen who normally take that role upon themselves to organize this unknown part of the supply chain.*
>
> *expert #11, IT solutions provider*

Serving these identities on a public Blockchain could make them universally accessible along the supply chain.

Overall, *enthusiasts* are the most advanced Blockchain users and advocates. They are not merely moving into the Blockchain space; they define it. They use the technology to its full extent and believe in business potentials stemming from Blockchain-enabled networks. This train of thought also clarifies *how* these companies are adopting Blockchain technology. These are explained and compared to the other company types in the next section.

5.2.2 The Organizational Adoption Path

The adoption of Blockchain requires some kind of organizational superstructure. Most prominent is the Bitcoin network, which maintains self-governance through technical means (Musiani et al. 2017; Filippi et al. 2016). However, most experts believed that a single company could not establish a Blockchain solution alone. An expert stated:

> *In the supply chain context, you cannot test something on your own. You have to work with consortia. And where do their resources come from? Is there an external company which is doing development, or do somehow the partners chip in and get it done?*
>
> *expert #22, IT solutions provider*

Thus, most companies seek to establish: (1) an organizational construct, (2) governance through an addressable entity, and (3) cross-industry market power. In the following, these observations will be elaborated.

5.2.2.1 Establishing Organizational Constructs

The experts perceived Blockchain as an ever-growing ecosystem that provides a ledger that all parties of an SC&L process can access. While solutions with a limited set of functions, such as transferring tokens in cryptocurrencies, work without a centrally organized instance, the experts assumed that Blockchain solutions for SC&L require cooperative structure. They also assumed that the typical cooperation type would be a consortium with rules and a leadership committee. An expert pointed out:

> *In our view, a typical intermediate step will be that [Blockchain in SC&L] will initially be an issue for consortia. Industry sectors and subsectors can agree to approach a cooperative platform that maps the industry's basic processes.*
>
> *expert #4, consulting company*

Experts extensively discussed the exact organizational type. One mentioned how different participants' influences will differ, noting that late joiners will control less:

> *Of course you can join any consortium later. Everyone is happy, because the bigger the consortium, the more powerful it is. However, you will join with different conditions; you have to pay a certain price. The most important argument is that you are not part of the core consortium that takes the lead. However, this is where you want to be. You want to control the development and, if you are in the lead, you can do so; otherwise, you are just an extra, going with the flow.*
>
> *expert #5, bank*

Other experts noted that the influences of the parties in the consortia would likely depend on factors such as the resource they have provided. However, these discussions about influence had other experts worried about bureaucracy or abuse of power:

> *If you have everybody governing something, it doesn't ever move it becomes too bureaucratic. So, if you are smart, you set up a smart governance system which is all-inclusive, so no one is left behind, everybody is heard, but it is efficient, it is fast, and it doesn't cause bureaucracy, then that is probably the best solution.*
>
> *expert #15, international trade association*

> *I had a meeting with a company. We talked about consortia and the role of consortia in Blockchain development. They said what their concern was that it is so centralized. Maersk seems to be taking too much of the lead. And as long as that is the case, they will never ever work with them.*
>
> *expert #4, research*

For *hypsters*, consortia are an opportunity to get involved in the Blockchain space. As noted, it's often possible to join a consortium at any time. A fee and a statement of intention can be enough to join. It does not imply that the company has to use or uses Blockchain. However, it boosts their external company communications. *Endeavorists* have a more practical perspective; they need a consortium as an addressable entity taking that takes the role of a central leader.

Enthusiast companies see consortia as a result of Blockchain's deployment, not necessarily as a leadership tool, likely because they are often product owners themselves:

> *We do collaborate closely with a number of other logistics companies. But if a brand wants to embark on a Blockchain project, then it's up to the brand to invite its partners in their ecosystem to participate.*
>
> *expert #20, logistics service provider*

> *What we see is that consortia are basically key because you don't sell [the Blockchain solution] to one company. You sell it to different companies, you actually need a consortium. It's not really a strategy. It's just a consequence.*
>
> *expert #23, IT solutions provider*

In sum, the experts agreed that some form of leadership is needed to run Blockchain solutions in SC&L. Examples in the literature, such as end-to-end tracing or cross-border documentation of goods, require a mutual agreement that describes all the supply chain participants' requirements (Sander et al. 2018; Loklindt et al. 2018).

Jabbar et al. (2018) reported that too few members in a Blockchain consortium hampers its growth. On the other hand, large organizational constructs tend to become complicated to work with because different companies may have different application intentions. Thus, a small group of companies with an aligned objective is likely to be more versatile. Zavolokina et al. (2020) and Wang et al. (2018) noted that an extension of the network is always an option as the solution matures and includes more functionalities. Thus:

Observation 1

Blockchain solutions for SC&L require an efficient organizational construct that allows for leadership and ideally represents the entire supply chain.

5.2.2.2 Establishing Governance

The main expectation for the organization (e.g., a consortium or cooperative) that deploys a Blockchain solution is to establish governance: On the one hand, it would look after technological and organizational advancement. On the other hand, the experts also thought that this organization should be a neutral entity, so as to decide in the case of conflicts or malfunctions.

> *You need an unbiased, neutral, and nonprofit body that coordinates and manages the governance, who does not benefit from anything other than making sure that the governance progresses well and all the users of the system equally and fairly benefit from the proper functioning of the platform.*
>
> *expert #15, international trade association*

Besides the conflicts, the establishment of data format standards was also discussed. The required data need to be well defined if companies are to be able to work with the Blockchain-based solution along the supply chain. The experts see this task as part of the governance: The design of the standards requires the mediation and cooperation of competitors:

> *They should also be able to mediate and resolve conflicts. It is a task that is undoubtedly the responsibility of such an organization. Also, the definition of standards, they are created together, and then the organization implements them.*
>
> *expert #8, logistics service provider*

> *[Ocean carriers] are fierce competitors; they begrudge one another. However, they have to agree on a standard because they have to understand one another. It is difficult for companies to set a standard. None of them can say: "I am the largest. I will work it out." Even the biggest one cannot do it.*
>
> *expert #19, logistics service provider*

The mediation and conflict solution functionality is most relevant to *endeavorists*, because they worry about possible future conflicts owing to errors or administrative mishaps. They plan to integrate the solution into their daily business and anticipate that the conflicts they have today will still be present in a Blockchain solution.

Overall, agreement on a set of governing actions is necessary to make a deployed Blockchain solution accessible to multiple parties. It also seeks to provide a sense of control to the companies that a fully decentralized solution may not provide. The organization that carries out governing actions (e.g., ensuring accessibility or meditating in case of data standards questions) does not necessarily need to be the same as the organizational construct that leads the Blockchain solution. It is possible to establish a workgroup on data formats or to invite an external company to mediate in case of conflicts.

However, the decentral solution provides accountability and transparency of what happened in the process. The governing actions would be necessary in case of an error in a decentral program (e.g., the *DAO hack*) or a possibility to misinterpret the functionality (Wüst et al. 2018). Regardless of how this type of institution would be integrated technically, for the trustworthiness in the overall system, the expert deemed it a necessity. They also felt that such a governing group should standardize data and create overall inclusiveness for new companies. The decentral solution will enforce the same data structure across all participants. However, the question remains whether all parties can provide these data and whether they are enough for all participants. Thus:

Observation 2

The governance mechanism used in Blockchain solutions for SC&L must allow for the creation of data standards, must solve conflicts, and must maintain an openness to adding new companies.

5.2.2.3 Establishing Cross-Industry Market Power

It is unlikely that a broad range of Blockchain solutions prevails. As an expert explained, this would lead to the fragmenting of the solutions, ultimately creating no value:

> *But of course, the moment you start creating one consortium, and then another one, and then another one, and then another one. […] you end up with the same situation – which is the many integrations. If I am a company and I need to support five customers, and I need to interface with five different systems to do that it's a self-defeating purpose.*
>
> *expert #18, manufacturer*

Thus, to be used as a quasi-standard, the deployed solutions must establish themselves in the market. One way is to provide a common interface to address a problematic process, so as to get the more reluctant companies on board. An expert stated:

> *There must always be a certain workforce or corporate power across the board to implement certain things. And then the shipping companies can also get together and say: "Okay, we have this process, how can we solve it together? Because this process simply eats up an incredible amount of resources of all of us." This may not be the competitive advantage for the individual company, but overall, in the logistics market. I also believe that it is also important for a certain level of customer satisfaction.*
>
> *expert #17, logistics service provider*

The experts also said that the idea of a decentralized formation of rules and standards may be somewhat threatening to market positions. Thus, a second way could be to first establish market dominance and gather the partners later. An expert outlined this strategy, using a large cooperation as an example:

> *It is just a very big defensive move. Maybe they are just deploying that to defend their own position because what is the win for them to do so? […] If you think about what Blockchain is about, it is a bit curious that this large company adopted it. […] That is for them also a way to set the terms.*
>
> *expert #1, IT solutions provider*

During the interviews, the need for cross-industry market power was mostly discussed by *endeavorists*. Having enough market power or joining the initiative with enough market power early on is important to this company type; they are afraid of betting on the wrong horse and seeing their business changed by an outsider. The *hypsters* mentioned in the conversations were expected to join the solutions later, when the market shares were clear – in case they decide to implement a Blockchain solution at all. Again, *enthusiasts* remained doubtful about some companies' intentions, but noted that using the solutions together is a necessity and that Blockchain is a cross-company tool to do this. An expert described this:

> *In the end, Blockchain is simply the guarantor. You say this transaction is now securely stored and traceable. Because with Blockchain, we have a technology and collaborative environment with partners who would not work together on a central platform.*
>
> *expert #21, manufacturer*

In sum, one organizational approach is to gather bargaining and market power. Various cooperative practice types support this, for instance, a joint venture between the largest transport companies could try to force a Blockchain solution on all market members. In contrast, companies can move forward, develop Blockchain solutions alone, and then force them on their customers and competitors.

The situation is similar to the Oklahoma Land Rush of 1889 (Hoig 2015): Vast possibilities of Blockchain SC&L are already available; now it seems critical to swiftly claim the parts that promise the most success. A technology push or merely requiring the use of a particular Blockchain solution is one route that companies take (Jabbar et al. 2018; Walmart Inc. 2018). The alternative is to build the application and grow its community organically by identifying partners in parallel or afterwards, which can be hard to achieve (Casino et al. 2019). When considering current solutions, the impression arises that many solutions only serve single supply chains, such as Everledger's diamond tracking and, therefore, have no need to grow beyond

the initial partners (Cartier et al. 2018). However, the benefit for manufacturers lies in the standardization of interfaces. Thus, these single supply chain solutions are prone to be taken over by more universal setups that include their functionality. Thus,

Observation 3

Blockchain solutions for SC&L require market power to be established and to acquire users.

5.2.3 Practical Adoption Path

The analysis yielded two perspectives on companies' adoption approaches: A more technological, practical perspective and a more business-related one. The first involves trialing Blockchain solutions, and the latter inspecting appropriate business models for Blockchain ecosystems.

5.2.3.1 Trialing First Blockchain Solutions

Companies typically do time-limited test runs – so-called trials or PoCs – to determine the technical capacity of their Blockchain solution and to evaluate their use case's fitness. In the interviews, the experts also explained that the trials were only partially held because a real problem exists, but also to test and learn about Blockchain technology generally. The trials are often conducted in multiple phases, getting more elaborate over time:

> *We are not participating [in the trial] to further develop the technology. We are participating to see whether the technology can deliver what it promises us.*
>
> *expert #19, logistics service provider*

> *I just want to get the trial going, and then we can build on that. That is how we learn and improve things.*
>
> *expert #20, logistics service provider*

In the technical testing, the reasons to get into the Blockchain have practical consequences. *Hypsters* are out of the picture at this point, because they lack the ability to do technical testing. An expert resignedly said this about their own *hypster*-type company:

> *I cannot just go to IT and say: "Yes, I would like you to do Blockchain now."*
>
> *expert #17, logistics service provider*

The key difference between *endeavorists* and *enthusiasts* lie in implementation pace and the willingness to move forward. *Endeavorists* are much more careful, trying to exactly define the use case, and getting external experience on board. An expert stated:

> *Work out the use case as clearly as possible and then think about whether Blockchain could be an application for it, and look at the existing technical approaches. And I would try to get either IBM or another big consulting firm on board that has already done a big Blockchain project.*
>
> *expert #8, logistics service provider*

Enthusiasts accept technical shortcomings to swiftly get their product into their SC&L processes, hoping that over time the technical problems will be fixed:

> *I am fine with getting information from a paper, put it in a spreadsheet, and upload it in the Blockchain. I do agree, it sort of defies the purpose of this technology. But this can be ironed out as the technology matures and as the processes mature as well.*
>
> *expert #20, Logistics service provider*

> *The more innovative, the farther ahead they are, and most likely, they already tried the Blockchain implementation with someone.*
>
> *expert #22, IT solutions provider*

In sum, regardless of the extent, the experts agreed that trials serve to evolve the Blockchain solution and to determine its eventual feasibility. Administrative and technical barriers cause a lack of enthusiasm among *endeavorists*, because they find these barriers more challenging to solve than *enthusiasts*.

Rapid testing of minimum viable products (MVPs) was proposed by Ries (2011) with the lean startup in mind (Rancic Moogk 2012; Ries 2011). However, this agile development is not limited to startups (Blank 2013; von See 2019, pp. 126–127). Blockchain solutions are multifaceted products that include software and hardware. Since Blockchain solutions are based on bleeding-edge Blockchain implementations that are continually developed at a fast pace, an agile, continual development cycle and careful testing are appropriate. The trials in practice have the potentials for companies to learn (see also Section 5.2.6 on page 128) and to quickly realize whether it makes sense to add further complexity and partners to the solution. Thus:

Observation 4

Blockchain solutions for SC&L require the anticipation of the supply chain actors' needs already during the development.

5.2.3.2 Designing Business Models for Ecosystems

In the interviews, the use of the Blockchain implementation as an asset was not considered feasible. The problem that companies seek to solve after or in parallel to their Blockchain trials is which part of the Blockchain solution could be a sellable product. Instead, experts noted that Blockchain implementation is the common infrastructure that can become the basis of business models. Two experts noted:

> *I think the money is on the application level and not so much in the protocol level. Unless you allow people who are just using the technology to actually run applications that can run regular business models, I don't think it's going to take off at all.*
>
> *expert #24, research*

> *Think of an infrastructure where others can pursue their business models and then earn money for themselves, but first we need a basis on which everyone can participate. That's the whole point of distributed ledgers: to create a structure in which everyone is involved and everyone has transparency, but only then are more far-reaching business models possible.*
>
> *expert #16, manufacturer*

According to the experts, a business model's innovativeness and strength based on Blockchain is the network that many companies trust and use. From the experts' perspective, a Blockchain implementation is a new platform type that allows even third parties to build their business on, but without a central owner of the platform who can change the rules. An expert explained:

> *Innovation happens in an ecosystem, which is quite open, where partners come together and where you share your ideas. Of course someone will copy it, but if I do not get it, someone will get it two to three months later anyway. This means you have to share the ideas; you have to gather talent and partners just to achieve this network effect.*
>
> *expert #10, electric utility company*

The step of building business models requires some experience from trials with Blockchain solutions. Otherwise, the companies have a hard time differentiating

between the implementation and the application levels. *Hypsters* are clearly out of the question for this approach. However, as outlined in Section 5.2.3.1 on page 105, *endeavorists* also have a hard time realizing this approach. A typical business model for a platform is to provide access to infrastructure (e.g., Facebook allows to show advertisements allows to show advertisements on the website they operate). The use of these infrastructures required contractual agreements with the infrastructure owners, which in turn protected their intellectual property (IP). The experts identified this protectionism as one of the problems holding back *endeavorists* compared to *enthusiast* companies, who consider this during development. Two experts described this struggle by *endeavorist* companies:

> *This is what I always try to explain to them, you are only part of the infrastructure to offer your services, but this infrastructure is not your IP. It will be nothing that you can gain an benefit from just because you are a part of it.*
>
> *expert #21, manufacturer*

> *When you are establishing such a platform, this is another way to manage. You need open ecosystem leadership, which is something German managers cannot do. They are used to being in the silo and making an IP clause for everything.*
>
> *expert #10, electric utility company*

Enthusiasts have collected experience in the Blockchain space and seek to build applications that live on top of private or public Blockchain networks.

Central platforms can lever their accessibility, and the ownership of the data – in short, their market power – to sell their service. Typically, in a Blockchain solution, the participants have to be part of the infrastructure. The Blockchain solution is an ecosystem that only works because of its participants. Thus, ownership of the infrastructure is no longer enough. Blockchain solutions require a benefit on the application level. The networks must be as open as possible to allow many companies to use the Blockchain applications with their partners.

Business models that use a Blockchain solution must carefully consider the process of growing these ecosystems during their design phase. As discussed in this section, it is unlikely that the business value will lie in providing access to a Blockchain solution operated and governed by a single entity. Further, a Blockchain solution's use has few benefits if it is merely a replacement of a single actor's API or platform.

For instance, if a grocery retailer replaces its purchasing interface with a Blockchain solution, for the supplier, this simply means serving yet another digital interface.

Several concepts describe how the ecosystem should work overall, for instance for companies in a diamond, meat production, or pharmaceutical product supply chain (Cartier et al. 2018; Abelseth 2018; Sander et al. 2018). However, Wang et al. (2018) noted that, for the creation of tangible business cases, Blockchain solutions should become value platforms. Value platforms are network configurations in which its members use "tangible and intangible resources" to "co-create value through a set of specific activities" (Perks et al. 2017). Although Wang et al. (2018) discussed possible business opportunities for operating Blockchain solutions, they also agreed that merely operating a Blockchain implementation is not a business case.

The literature has also shown that the opportunity to openly access a Blockchain solution is a benefit and a major driver of an ecosystem (Foth et al. 2017; Dujak et al. 2019; Loklindt et al. 2018). The data available on the Blockchain could lead to "new forms of interactions between consumers, producers, and processors" (Foth et al. 2017), for instance in the transportation sector (Dujak et al. 2019), but also in other sectors, because end-customers can now directly access the data (Foth et al. 2017; Dujak et al. 2019; Loklindt et al. 2018). Thus, analyzing the data available on Blockchain and providing relevant learnings could drive business cases (Casino et al. 2019).

The Maersk and IBM joint project *TradeLens* that sought to digitalize international shipping documentation is an example of the importance of openness of these Blockchain solutions to grow into ecosystems (Jabbar et al. 2018). A project's lack of traction is a result of the absence of openness (Jabbar et al. 2018). Thus:

Observation 5

Blockchain solutions for SC&L should be designed to allow the growth of an ecosystem around the focal supply chain to allow the supply chain members to benefit by creating additional business models on the same solution.

Observation 6

Business models for SC&L should use the Blockchain implementations as an infrastructure or an operating system, not as its integral part.

5.2.4 External Barriers

External influences faced by companies, and the associated difficulties in changing these, limit the extents of companies' adoption efforts. In the course of the interviews, four external barriers were identified: (1) Uncertainties concerning how Blockchain solutions would comply with regulations, (2) technical limitations of existing Blockchain implementations, (3) the lack of readily available off-the-shelf solutions, and (4) the challenges in associating physical assets with Blockchain transactions. The reasons and consequences of these barriers will be explained in the following.

5.2.4.1 Regulatory Uncertainties Regarding Blockchain Solutions

Because Blockchain is a fairly new technology, no case law exists. However, in the companies, aspects of the possible regulation scenarios and consequences of violations are discussed. The possibility that a company could do a transaction on Blockchain that later proves to be irreversible yet legally should be reversed, causes worry, especially for user-related data. Multiple experts pointed out that the General Data Protection Regulation (GDPR) and privacy regulations implications concerning Blockchain are not always clear-cut. Two experts pointed out the dilemma of the possibility of being unable to comply in the future:

> *It is always possible that laws change, and that the infinity [of data storage] then turns out to be a problem. It clashes a bit with the "right to forget". Especially since it is possible to identify the de facto user by triangulation, even with pseudonymized data.*
>
> *expert #2, consulting company*

> *If you use public Blockchains, you have more risks in terms of regulatory compliance because you run the risk that, in three months, the European Commission has put a ban on Ethereum and Bitcoin.*
>
> *expert #15, international trade association*

Further, the laws vary in different countries, not only concerning privacy but also trade. The experts stated that, especially in worldwide systems, the lack of guidance from public bodies and existing incompatibilities of laws could make Blockchain solutions incompatible with individual countries:

> *It is currently of great concern to us to clarify these regulatory questions and to somehow really clarify them for the North American region, for the African region, for the European region. To check: is what we do compliant, or do we have to improve? This will definitely be one of the biggest hurdles on the way from a proof-of-concept or pilot stage to marketability.*
>
> *expert #5, bank*

> *Data protection, encryption, also legal. Who has sovereignty over the data? Looking at the EU data regulation requirements, I would not want to have to answer this for Blockchain. And these are the barriers.*
>
> *expert #8, logistics service provider*

The experts also wondered how companies will deal with legal disagreements on technological questions in practice. If a decentralized program does not behave as expected by the contracting parties or in cases of abuse of these programs, it may be hard to find acting counter-parties.

In short, this external barrier stems from an overall uncertainty regarding the resolution of practical legal questions, because no practical experience exists and the different countries' rules and regulations can contradict one another. There was no indication in the interviews that the different company types have different positions regarding this barrier.

Many Blockchain solutions in SC&L are international, which means that it is hard to assess the consequences of new laws targeting privacy, trade barriers, and other national restrictions. In the literature, the discussions of the lack of compliance requirements and legal fundamentals of Blockchain are typically about cryptocurrencies, but research into SC&L has noted the same lack (Lacity 2018; Saberi et al. 2018; van Engelenburg et al. 2019). Different countries often have few plans to implement legislation on Blockchain, and even less on the cross-border questions of SC&L Blockchain solutions (Low et al. 2020). Consequently, this barrier will likely remain in place for the next years. Thus:

Observation 7

Unclear legislation hampers Blockchain solutions for SC&L.

5.2.4.2 Technical Limitations of Blockchain Implementations

Trusting a software solution to be used in a company's productive system requires the confidence that it will do the job. Regarding Blockchain solutions, in SC&L practice, the experts mostly agreed that the current status of Blockchain implementation is not feasible for production use. The main reason is the limited write speed; traditional databases are much faster. One expert noted:

> *You don't have transactions immediately; you still need to wait fifteen seconds or whatever. And there are less and less reasonable cases or less and less reasons to make some cases reasonable, to explain why Blockchain has to be there.*
>
> *expert #22, IT solutions provider*

A second reason is that the experts found the Blockchain implementations to be less reliable than they expected them to be. They also noted that it is hard to fix errors or adjust for new features, owing to a lack of up-to-date documentation. Two experts described:

> *Then the viability of such a solution, maintainability; for example, Hyperledger, the code is so unstable; if you use it operatively, you can hire five persons who only update Hyperledger and straighten the interfaces. This is not possible at the moment.*
>
> *expert #8, logistics service provider*

> *This change of Hyperledger Fabric from 0.6 to 1.0 caused us a lot of trouble. […] But that is how it is, that is how the technology works; it is a constant battle against time. And Version 1.0 does not run very stable now. They also have their problems with the code, concerning single nodes, the mass, the scalability. […]*
>
> *expert #5, bank*

Taken together, the scalability problem and the complications for the software developers render the deployment of Blockchain applications difficult.

While *enthusiasts* are aware of these troubles of Blockchain implementations, they embrace them and are more aware of what the limitations mean for the Blockchain solution and how to mitigate them. An expert from an *enthusiast* company type said:

> *It's true; the technology isn't mature. The question is, how bad is it?*
>
> *expert #23, IT solutions provider*

Again, *endeavorists* consider this to be a larger barrier than *enthusiasts*. *Endeavorists* either lack the experience, or see the lack of scalability as a key disadvantage, especially compared to other software. Even Blockchain solution providers acknowledged that:

> *It is important to understand that we are in a beta phase.*
>
> *expert #11, IT solutions provider*

The literature also shows this weakness or lack of maturity; nonetheless, issues such as the low number of transactions per second, the high complexity of Blockchain solutions, usage difficulties, and the associated high development costs are considered solvable in the future (Abelseth 2018; Casino et al. 2019; Hinckeldeyn et al. 2018b; Hofman et al. 2017; Lacity 2018). Thus:

Observation 8

Companies currently consider Blockchain solutions to be not mature enough for productive use for SC&L.

5.2.4.3 Missing off-the-Shelf Software Solutions

Blockchain solutions for SC&L being tested or piloted today are specifically custom-built systems. Some of the experts pointed out this need for manual development and the lack of readily available solutions. Further, they maintained that the solutions could be fairly elaborate:

> *To set this up properly, you need to have someone who is behind it full-time. I suspect that many IT departments do not have the time and resources to commit to this. […] There are thousands of different frameworks, and they all say "it is so easy with us," "one click" and that is simply not true*
>
> *expert #2, consulting company*

> *Our solution is pretty much tailor-made. At the moment, it is case by case. We say exactly: "Okay, in this transaction, we need exactly one party who takes over the function of the customs office, and they have to see exactly these data" […] In the future, there will probably be such ready-made frameworks.*
>
> *expert #5, bank*

This situation holds companies back. An expert confirmed:

> *Blockchain is not nearly ready. It is just getting started, and there are already other ready-to-use systems and solutions you can just buy. For Blockchain, everybody does their own thing.*
>
> *expert #17, logistics service provider*

The companies would like to purchase a solution and adjust it to their requirements. According to the experts, such a solution may be available in the future.

The discussion with the experts also revealed that it's not easy to integrate Blockchain applications into other business software. The existing software that companies use is feature-rich: ERP systems manage complex product workflows and have user interfaces and APIs. Two experts provided insights into this problem:

> *Their internal systems often don't have an API, or they have a very bad API, or they use XML files on a shared drive. So, in general, the integration part is problematic, not because it's difficult, but because it's painful, and it takes a lot of time. And it is costly.*
>
> *expert #23, IT solutions provider*

> *At the moment, everybody is doing proof-of-concepts, and they fire up Ethereum and say: Hey, look, we got a bunch of Blockchain going. […] But you've also gotta think about how to integrate with an ERP system. How do you get data from SAP or Oracle? How do you integrate with present data systems? How do you integrate with workflow systems?*
>
> *expert #9, IT solutions provider*

Overall, in sum, companies face a lack of enterprise-ready software during the adoption of Blockchain solutions. The experts also pointed out that there are no easily adaptable and deployable out-of-the-box Blockchain solutions, making it an additional barrier because the manual development and maintenance are costly.

Endeavorists, and *enthusiasts* would welcome buying a software package that is easy to configure and that they can have their IT department deploy. However, currently, companies need specialized service providers for Blockchain development and consequent deployment in different companies. The removal of this barrier is a prerequisite for *hypsters* and *endeavorists* to consider using Blockchain solutions in practice. Both these company types consider the costs of the manual development to be excessive, concentrating instead on readily available software solutions. As outlined in Section 5.2.4.2 on page 113, *enthusiasts* are more accustomed to the possible problematic situations and often take the manual development route to create tailor-made solutions.

Blockchain implementations lack technical maturity, on the one hand (Kouhizadeh et al. 2021; Hinckeldeyn et al. 2018b). On the other hand, the use cases in SC&L are currently still highly individual configurations (Queiroz et al. 2019a; Casino et al. 2019; Tönnissen et al. 2020). Both aspects make it hard to create a software framework that practitioners can use to build on. Custom, individual configurations are necessary for the software systems of the companies and each interface to the company's software, such as ERP or WMS systems. Further, the responsibilities for network nodes and operations are highly use case-dependent. Thus:

Observation 9

To be used broadly in practice, Blockchain solutions for SC&L require adaptable software frameworks that are capable of connecting to intra-company software systems.

5.2.4.4 Association of Physical off-Chain Objects Is Challenging

One of the biggest promises of Blockchain for SC&L is the inclusion of near-real-time data about goods. Single objects have to be labeled individually for handlers to then sign each process step or IoT sensors to feed state changes into the Blockchain application. Typically, the idea is to execute automatically upon state changes of goods, for instance, out-of-range temperatures, sensing shock, or deviation from the planned paths. However, the experts stated that associating physical objects and off-chain data with Blockchain is a complex problem. The communication with the Blockchain must be truthful – tampering with the physical link, for instance, a label or an RFID chip between the Blockchain and the good would render the whole solution useless. The same occurs if a solution requires access to external data feeds (e.g., temperature readings), which can be incorrect or altered. Although all followup records may be correctly signed, the overall record would be incorrect or assigned to the wrong good.

> *Who can guarantee that the data that enter the Blockchain are correct? […] How do the data enter the Blockchain? At the moment, many possibilities to manipulate data remain, and these data remain on the Blockchain forever. Everyone works with these data, but perhaps they are not correct. This is a problem that the Blockchain cannot fix.*
>
> *expert #5, bank*

> *In principle, the data is just as good as the input at the end of the day. Unless you have those things that are secure and are done properly, I think you are going to end up with very nice and secure Blockchains but are completely useless.*
>
> *expert #24, research*

Besides the possible tampering with the physical link, the triggering and automatic execution of actions may also remain a pipe dream. In the discussions, it became clear that even seemingly straightforward cases require extensive context data and multisensor networks. The experts provided examples:

> *If you have a more complicated case in the back of a truck, for instance if you have broken glass. You need context data, what the road conditions were, things like that. You have to analyze it. For this, you need decentralized analytics, and I think the technology is not yet that far.*
>
> *expert #21, manufacturer*

> *It is not enough that I just put a temperature sensor in there, I have to have four or five that cover the entire container and also look at how the air is blown in and out. Is the cargo stowed in such a way that the air can flow? Is this an incorrect load, for which we would be liable? Or has the container somehow failed?*
>
> *expert #14, insurance*

> *You have to look at the data source, at the reliability. Because there are other factors in the real world, and a Blockchain does not notice them by itself.*
>
> *expert #13, logistics service provider*

In sum, the learning is that establishing a reliable physical link between off-chain assets and essentially verifying off-chain data is a complex undertaking: The link must be tamper-resistant, and the data must be reliable. Further, simple sensor readings are often not enough to determine the necessary next steps.

Again, this barrier to Blockchain adoption is not specific to a company type, because it depends on the planned use case. However, for *endeavorists* who seek a way to integrate Blockchain into their regular business, this can be another stumbling block that holds them back.

Some companies provide specialized hardware to address this problem, although currently this hardware is too expensive for mass application, (e.g., for food or fast-moving consumer goods). However, specifically in SC&L, the need for a physical pairing between an object and its Blockchain entry is a requirement to make the applications useful. Solutions for the textiles or the food industry may require this link for every single item, for instance, a left or a right shoe, or each avocado in a box (Swan 2018). Current solutions, such as individual barcodes or RFID tagging, are complex and are either not tamper-proof or challenging to deal with along the supply chain (Cartier et al. 2018; Sander et al. 2018; Wüst et al. 2018).

The whole tracking in these cases relies on a correct initial pairing and continually maintaining this pairing during transit. Thus, an elaborate concept is required to make the pairing reliable, to ensure that the data from sensors is correct, and to enforce physical access to the object identifier. Yet, even after all these measures, there is no guarantee along the supply chain that the entity making the entry in the Blockchain does in fact have physical custody of the item (Wüst et al. 2018; Wang et al. 2018). If all this is ensured, Blockchain can serve as a basis for artificial intelligence approaches, because it has historical records not only of handling points but also of cargo conditions (Gill et al. 2019). Thus:

Observation 10

Association and identification of physical objects is a requirement for Blockchain solutions for SC&L to work. To fulfill this requirement, the methods used for this identification must be tamper-resistant, reliable, and inexpensive.

5.2.5 Internal Barriers

Internal barriers to Blockchain adoption are more individual to each company. The three barriers presented in the following were pointed out by multiple experts: The first is the lack of sample use cases for SC&L. This barrier inhibits managers from deciding to enter the Blockchain space. The other two barriers concern the possibilities of industrial espionage and a possible loss of competitive advantage. Both are based on companies' overall strategic decisions.

5.2.5.1 The Lack of Sample Use Cases for SC&L

The experts noted a surprising lack of well-documented use cases with experiences that companies can learn from. Having no examples makes it hard to evaluate Blockchain projects' consequences:

> *You have to be clear: each business case is fake news. All the parameters are very unclear and have a vast range. When will the technology appear on the market?*
>
> *expert #10, electric utility company*

> *I have found very little literature that connects Blockchain with supply chain management, and when they talk about the supply chain, they usually talk about very specific things. […] The whole supply chain, from sales to delivery from the start of an offer to the end of a contract, that I haven't really seen reflected anywhere.*
>
> *expert #18, manufacturer*

The experts also affirmed that, besides a lack of descriptions and reports from practice, there are very few reports from larger-scale, complex projects or their benefits, even from companies from which one would expect technological advantages. An expert stated:

> *Even if you look at IBM, SAP, all the big technology companies, the use cases they have with Blockchain are all fairly simple.*
>
> *expert #20, logistics service provider*

Instead, the understanding during the discussions was that the reports have little detail and are limited to small-scale PoCs. There is often is little helpful information available on how Blockchain trials turned out.

This barrier is holding companies back from embracing Blockchain solutions, but it is also something of a chicken-and-egg problem: On the one hand, there is a lack of sample use cases that companies can rely on, making it hard to decide whether Blockchain will provide a long-term benefit. On the other hand, this also leads to fewer practical projects and publications about these.

For *endeavorists* and *hypsters*, such use cases would make it easier to decide. Especially for the *hypsters* who lack the technical understanding and therefore must strongly invest in technical support for a Blockchain solution. Further, it is hard to argue that Blockchain solutions are beneficial if even the *enthusiast* experts do not know a trustworthy large-scale use case currently in productive operation. Currently, *enthusiasts* often build small-scale PoCs or pilots themselves, and mostly aim for a larger scale. *Enthusiasts* believe that they will be able to solve future problems once they arise. The literature refers to this as the lack of a "large quantity of robust case studies" (Bhattacharyya et al. 2018), which is attributed to a lack of empirical evidence (Wang et al. 2018; Hofman et al. 2017) and not to a barrier that prevents Blockchain projects. However, the results suggest the latter. Many use case descriptions are merely short descriptions of PoCs, media releases, or other marketing material. The lack of empirical material (as shown in Chapter 3 on page 21) makes it even harder to build elaborate use case reports for practice. Thus:

Observation 11

The lack of sample use cases that include experience form practice make companies hesitant to adopt Blockchain.

5.2.5.2 The Possibility of Industrial Espionage

The problem of competitive business intelligence or industrial espionage owing to privacy leaks is the second internal barrier uncovered during the interviews. A Blockchain solution may allow customers and competitors of a company unintended insights into the business. An expert stated:

> *[…] Patterns of metadata: Even if you don't know the content, just as people exchange messages in the chain, you can guess what they are doing*
>
> *expert #8, logistics service provider*

Triangulation of these metadata can unknowingly expose confidential information to outsiders. The parties who can see the transactions may also use these data to extract information beyond the intended business case. On the other hand, some companies are looking forward to doing exactly this. An expert pointed out that having access to more data could help immensely to streamline processes:

> *For the business intelligence department, the data are also incredibly interesting from the evaluation side. […] You can have a precise listing, including times: when exactly and where is my container handed over to whom; to identify bottlenecks: Where does it always take particularly long, or are there certain providers that take longer. […] Currently, some processes are not visible to us. […] And the Blockchain would make it possible to record this.*
>
> *expert #17, logistics service provider*

Overall, the possibility of leaking data is a threat noted by the companies, because they would be more vulnerable to competitor espionage and customer demands. Mitigation of this barrier is not trivial unless the Blockchain implementation develops further. Currently, the companies only have the option to decide that sharing these data will not affect them. *Endeavorists* are aware of this barrier. They will only decide to move to a Blockchain solution if the implications of the availability of these data are clearly assessed and equally accessible to everyone. *Enthusiasts* weigh-off and pointed out that it is (1) better to start an initial PoC to assess which data are shared and if these data are not already available in another way anyhow, and (2) that this discussion also happens in other setups:

> *I think that it takes a lot of discussion and time. For instance, if you look at sharing data in a community. You have a legal department that says, "Okay, but who will you share the data with? Is it our data that we are sharing or data from our customers, etcetera?" But you have the same discussion if you start putting data on a cloud platform.*
>
> *expert #23, IT solutions provider*

Overall, *enthusiasts* consider data-sharing a core part of Blockchain technology and are less worried about possible consequences.

The discussion about privacy-preserving Blockchain transactions is ongoing (Buterin 2016; Kosba et al. 2016). While some Blockchain implementations for cryptocurrencies provide possibilities to hide transaction information (Quesnelle 2017; Möser et al. 2018), implementations that SC&L setups would use have not resolved this problem (Casino et al. 2019; Hackius et al. 2019; Dujak et al. 2019; Wang et al. 2019). Companies in a fiercely competitive field can likely not afford to share any information with their competitors, yet Blockchain can be used to gain access to this information (Wang et al. 2019; Kouhizadeh et al. 2021; Hackius et al. 2019; Reimers et al. 2020). Thus:

Observation 12

Blockchain solutions for SC&L may make companies prone to industrial espionage, as transaction data and metadata allows for the drawing of conclusions regarding their business.

5.2.5.3 Fear of Losing against the Competition

Advantages in the market and over competitors through using a Blockchain solution were discussed in multiple interviews. For the most part, the opinion was that Blockchain would have a positive influence. However, it was also mentioned that the competitiveness gains could be hard to grasp. The experts indicated that it is a tough decision to join or create a Blockchain solution without knowing whether or not there is in fact a monetary income, and concerning the prospect of having to work with competitors:

> *How do I make any money doing that? There is no monetization at its core. You build such a decentralized platform, and the monetization comes at the edge when I manage to deliver for the people on the platform. That I optimize, aggregate, and give back as a commercial benefit and insights for better personalization.*
>
> *expert #10, electric utility company*

> *Blockchain is typically about the community. It is called the coopetition paradox. Blockchain is kind of new in a way that forces different entities, different companies, to work together. […] I think where we see the most difficult part is if we enter into the Blockchain, what will happen? How will that impact our business model? What will be the business case? We will be paying what?*
>
> *expert #23, IT solutions provider*

Further, there is no intellectual property in the decentralized solution, because all participants can use the Blockchain and typically have equal possibilities.

> *Why should I contribute to a shared infrastructure in which my competitors can participate? I think this is the biggest problem. Where are my exclusive rights, where is my intellectual property, where is my advantage? […] These are questions that corporates ask themselves. They therefore very much take a wait-and-see position.*
>
> *expert #21, manufacturer*

Competitive pressure persists or is increased through a Blockchain solution. Companies' decision-makers fear losing existing competitive advantages if they join a Blockchain solution, because they will then share the same infrastructure.

Unsurprisingly, this barrier is thought of differently by the company types. According to the experts, there is somewhat of a *wait-and-see* attitude, because the software they currently use works. SC&L managers have no acute pressure to update it and are instead worried about the problems that a new solution may create. One expert illustrated this worry about change:

> *It's very hard to convince managers that they should change it. Unless you can really, really show them that while today [the process is running] okay, if you add Blockchain, tomorrow it will be super-hyper-fantastic. Because any change is a huge risk, and unless you can quantify and manage that risk, people will usually not go for it.*
>
> *expert #18, manufacturer*

Even *enthusiasts* can sympathize with this thought. An expert affirmed:

> *Of course, we believe that Blockchain will be the future at some point, but what we see at this point might not be coming within the next very short years.*
>
> *expert #22, IT solutions provider*

However, *enthusiasts* are also choosing a more extensive adoption path. As outlined in Section 5.2.3.2 on page 108, their adoption strategy includes application-building on top of the Blockchain network. In this way, *enthusiasts* do not necessarily face this barrier, because they assume that the infrastructure is a public good or is readily available:

> *We use other people's infrastructure or pay to be allowed to use it. And if our customers want to set up a private Blockchain now, they are welcome to do so.*
>
> *expert #13, logistics service provider*

Tönnissen et al. (2020) investigated 10 Blockchain business cases for SC&L. They found new applications in only four cases; the other cases aimed at replacing or creating intermediaries. However, existing SC&L companies are usually not in the business of replacing intermediaries. Their value proposition is to provide SC&L services. They look for ways to enhance these services rather than to replace other businesses. Other authors also found that Blockchain business models in SC&L are lagging compared to other industries, but partly attribute this to the complexity of the supply chain networks, the infancy of Blockchain technology, and overall

insecurity regarding Blockchain's benefits (Queiroz et al. 2019b; Saberi et al. 2018; Wang et al. 2019).

More Blockchain-based applications will likely enter the SC&L markets in the future, because there are clear value propositions of using Blockchain solutions (Morkunas et al. 2019; Tönnissen et al. 2020; Queiroz et al. 2019b). Thus, at some point, companies may be required to join a Blockchain solution. The conclusion from the interviews is that the possibility of cooperating on infrastructure induces doubt that the Blockchain solution provides a competitive advantage. This finding is in line with the tradeoffs between competition and cooperation described in the literature (Luo 2007). Thus, it can be assumed that, until rivaling solutions are established in the market, or until collaboration brings additional benefits, the current competitive position is better. This is especially true if the Blockchain solution does not create additional value propositions for the company's customers. In the future, however, Blockchain first movers may have the upper hand because they are already well acquainted with Blockchain solutions and requirements. Thus:

Observation 13

Some companies recognize that Blockchain solutions for SC&L pose a threat to their competitiveness.

5.2.6 Learnings

The discussions also uncovered the experts' learnings, based on experiences during the adoption process while working on barriers and reflecting on the reasons to enter the Blockchain space. Thre were two major learnings, sharing data and driving digital transformation, and two minor ones, the rise of new gatekeepers and Blockchain's suitability. In this section, these learnings and how the different company types handle these are discussed.

5.2.6.1 A Blockchain Solution Requires Data-Sharing

A primary learning for companies investigating adopting a Blockchain solution is the need to discuss the data to be shared in great detail. The required a paradigm shift toward data-sharing was a common observation. The experts agreed that working with the same data across the supply chain holds enormous potential.

> *Everyone is sitting on data treasures, and their full potentials can only be realized when all your data are brought together. […] Everyone can keep their business model, but we benefit from this common approach. It is a question of the mindset.*
>
> *expert #5, bank*

> *The real added value is probably given when you write onto the Blockchain, to the same database, and everyone agrees on these data and also exchange information on this Blockchain.*
>
> *expert #8, logistics service provider*

These data are currently organized by each company individually and are passed on manually step-by-step, if at all. Blockchain could be facilitated to make data available across multiple parties. Two experts explained this situation:

> *It is a sector where there are many, many parties involved. So if you ship a container, let's say from Asia to inland Europe, you have easily twenty to thirty companies that touch the physical container. They all need to share data, which is not really happening.*
>
> *expert #1, IT solutions provider*

> *The way that supply chains are organized at the moment from a technology viewpoint is basically a patchwork of silo-based systems. And this just doesn't make sense. Why don't we all work on the same distributed ledger, on the same single version of the truth?*
>
> *expert #20, logistics service provider*

The experts also agreed that sharing could provide the basis to improve current processes and allow for new value propositions:

> *Counterfeiting is a big issue with all luxury goods. For these, we are creating a shared database, a single source of truth, in a Blockchain. […] You can apply to all kinds of use cases when you say: Okay, the logistics steps all have a connection to the single source of truth.*
>
> *expert #3, IT solutions provider*

> *It is becoming accepted more and more that you have to let everyone participate, first concerning data and data qualities, and then build on that. […] This is the point of distributed ledgers, that you can create a structure in which everyone is involved and everyone has transparency. And this structure makes business models possible.*
>
> *expert #16, manufacturer*

The idea for everyone to see and share across the process requires all members to use the same data formats. In the discussion, the experts regularly stated that the data-sharing process is accompanied by the need to create standards.

> *In the end, without standards, there is nothing. Of course, a few more would have to come together and agree on minimum standards, and if the network effects are on it, the whole thing works.*
>
> *expert #10, electric utility company*

> *Standardization, uniform data formats, this is certainly an important component of this platform's success.*
>
> *expert #5, bank*

However, standardization requires market power and a willingness to provide and share these data. One expert critically remarked that while it's possible to use the

existing UN/EDIFACT standard, this standard already has multiple, incompatible, local lingos:

> *No ship owner has implemented the bill of lading interface, the EDIFACT interface, in precisely the same way. They all have their variants. And then of course something like Blockchain does not work.*
>
> *expert #12, IT solutions provider*

Standardizing data structures for sharing using Blockchain also entails the questions of the extents and access permissions to the shared data. As described in the barriers section, the possibilities of industrial espionage (see Section 5.2.5.2 on page 123) and regulatory uncertainties (see Section 5.2.4.1 on page 111) should not be overlooked when considering data storage on the Blockchain. On the other hand, storage outside the Blockchain (off-chain) introduces additional technological requirements and possible limitations toward immutability. The experts' main point here was that as few data as possible should be shared on the Blockchain:

> *You can simply decide not to put the data in a Blockchain, which can be sensitive or be subject to regulations.*
>
> *expert #20, logistics service provider*

> *In general, it is better to keep a minimum amount of data on the Blockchain - and that should just be the data that is required by those particular parties in that particular transaction.*
>
> *expert #9, IT solutions provider*

> *There are technologies [for Blockchain] that allow for data scarcity and still allow a secure data exchange. An exchange of data in such a way that it can then also be proven that everything went well with the part for which you take responsibility.*
>
> *expert #13, logistics service provider*

In sum, data-sharing is required in a Blockchain solution, likely making company data visible to more process participants than is currently the case. The number and storage of shared data must be considered with care: A setup that imposes too many restrictions, possibly not storing all necessary data on-chain, will attract too few participants. On the other hand, world-open configurations can attract many

participants, they can make it hard for participating companies to protect their data.

Endeavorists are more skeptical about this aspect – data-sharing is something they wish to avoid:

> *I think the companies still come from the age of industrial espionage, and this is still very firmly anchored in the compliance rules. And of course then those who take the decision probably become personally liable.*
>
> *expert #21, manufacturer*

However, *endeavorists* also found that emerging Blockchain solutions may expect them to share data. This understanding leads them to the learning that data-sharing is required to maintain their competitive position. An expert explained:

> *If the business would go very well, and there would be no threat to their market share, I believe that nobody would make this step. But they realize that sharing data should happen much more than in the past.*
>
> *expert #1, IT solutions provider*

Enthusiasts enter the Blockchain space already aware of data-sharing as a key requirement. They often see Blockchain as an open space. An expert stated:

> *Innovation happens in an ecosystem, which is quite open, where partners come together and where you share your ideas. Of course someone will copy it, but if I do not get it, someone will get it two to three months later anyway. This means you have to share the ideas; you have to gather talent and partners just to achieve this network effect.*
>
> *expert #10, electric utility company*

Again, *enthusiast* Blockchain pioneers suggested that the adoption paths could start with much more lightweight solutions instead of spending much time defining data standards. An expert gave an example:

> *We had different actors saying: "If only I had the original packing list" or "if I only had the original document of someone further down the line in the supply chain, then things could be able to move better." […] You can just start by taking pictures of the documents, right? You don't have to start with having a unified format for how things are registered.*
>
> *expert #11, IT solutions provider*

Again, in this regard, *hypsters* do not experience this learning. However, they will profit from their cooperative partners who do have this experience and will likely have to comply with existing data-sharing rules if they decide to adopt Blockchain in the future.

The Blockchain applications for SC&L described in the literature depend on the exchange of transaction data (Casino et al. 2019; Tönnissen et al. 2018). van Engelenburg et al. (2018) reported that Blockchain use had clear usage advantages for providing access to data.

Companies on their path to Blockchain adoption will learn that data-sharing is necessary. They must provide data to the network, but also gain insights themselves. The extent of data should be as much as necessary but as little as possible; not all data must be stored on the immutable ledger. The public or private access to the Blockchain will depend on which applications gain traction as well as the number and the willingness of the participating actors.

More transparency in the processes seems to be a more attractive value proposition, but also intensifies competition, at least for standardized services, and could expose company data. Although still in development, no optimal solution that preserves privacy and provides end-to-end confidence for SC&L exists as yet. Thus:

Observation 14a

Blockchain solutions for SC&L require companies to share data with partners they currently do not need to share data with.

Observation 14b

Blockchain solutions for SC&L should limit the data stored on-chain to the minimum required in order to secure all the partners' trust.

5.2.6.2 Driving Digital Transformation Is Required

The second major learning is that there has to date been insufficient digitalization in SC&L. According to the experts, recording each activity relating to a product on its way through the supply chain is essential for Blockchain solutions. Manual steps or media discontinuities are no longer possible; every action originally executed via fax, phone, e-mail, or XML file transfer now requires a twin step to create a corresponding transaction record on the Blockchain. In fact, much communication is still carried out in analog form, even on paper, as the experts described:

> *There is still a lot of EDIFACT technology from the eighties, and next to that, there are many phone calls, many e-mails.*
>
> *expert #1, IT solutions provider*

> *In Asia, even in Australia, many warehouses involved in the pharmaceutical industry are still paper-based. That means the pallet arrives, it is written on paper, and then somebody runs to a terminal to enter the information in a warehouse management system. Then you arrive at a huge gap between a paper-based process and a Blockchain process.*
>
> *expert #20, logistics service provider*

> *In any case, I would say that all these processes, which are still based on paper, need to be digitalized. […] And I think many processes are incredibly bloated because they have not been yet digitalized, as certain verification procedures were missing.*
>
> *expert #17, logistics service provider*

However, Blockchain's properties also allow for new or repeated approaches to digitalizing processes. Blockchain can be used as a lever to compel companies along the supply chain to incorporate digitalized processes. One logistics expert described this approach:

> *Blockchain is not complex IT. […] It does not offer business logic or features like that. You can do a lot with it; we could do all of that before, but failed. Let us try that again with another technology that can perform some steps better than before.*
>
> *expert #8, logistics service provider*

The experts made it very clear that merely superimposing Blockchain on any process is not going to realize this technology's full potentials. Blockchain offers the opportunity to fully embrace digitalization and, in some cases, to even improve the process. An expert pointed out:

> *What you often try today is to take already existing processes and transfer them one to one to Blockchain. I don't think that this is the right approach. Then you have merely changed from one technology to another, which is sometimes more or less useful, but you can only get the real benefits if you alter the processes.*
>
> *expert #2, consulting company*

> *Redesigning things and processes, you might not even end up with a proper Blockchain system. But by engaging in a Blockchain workgroup, trying to figure it out, you might realize the weaknesses of what you have and find out that it's easier just to tweak the system and get a better workflow rather than implementing a square new system.*
>
> *expert #24, research*

Tinkering with the processes and experimenting with new solutions is part of a company's digital shift. As with any new digital technology, Blockchain requires the same process. Thus, starting with a small PoC is as much part of adopting Blockchain as redesigning the company processes for digital continuity. Two experts explained:

> *The more practical approach is minimal viable solutions. Figure out if it works, twist, move on. You do not have everything defined upfront. […] It is about getting out there, test it, and see what happens.*
>
> *expert #11, IT solutions provider*

> *Just get started with a small proof-of-concept. Such partial implementations take around two to three months just to get a real idea of the technology, to technically understand how it works. The organizational matters come with time. […] Start, and if possible, with a very simple use case, in order to experience what it means to develop a Blockchain platform or application.*
>
> *expert #5, bank*

In short, media discontinuities will hardly be possible in a Blockchain-based process. To close these gaps, companies must align their processes and digitalize them as a minimum requirement. Deploying Blockchain is just one part of a company's digital transformation. However, experimenting and rapid development cycles are needed if one is to stay on top of the rapidly evolving technology and the related markets.

Enthusiasts have moved beyond the digitalization discussion. For them, Blockchain is a part of a general digital shift within companies that should grow to the next level:

> *Big tech companies were identified [by a big shipping line] as being their main competitors, and not so much other shipping lines. This is about getting to be the ones that have a piece of the pie of the future portal for shipping. That was part of the larger digitization strategy that they were working with. A subcomponent of it was Blockchain.*
>
> *expert #24, research*

> *Right now, companies are just doing a lot of concept work and talking to startups, and then they start building prototypes, and that is where it ends for the moment. […] From my perspective, the next step would be to make it big, to build capabilities.*
>
> *expert #10, electric utility company*

The results also showed that Blockchain can be a useful approach to enforce digital transformation along the supply chain, because a process that uses Blockchain does not unfold its true potentials if it is limited to just a few companies. In the literature, Blockchain has been recognized as an "application for the digitalization of the entire international trade" (Dujak et al. 2019) and as a way to establish digital management systems and accelerate cross-company digitalization (Korpela et al.

2017). Further, the literature shows that Blockchain yields the most substantial benefits where end-to-end data continuity in SC&L is required (Casino et al. 2019; Wang et al. 2018). A qualitative study investigating Blockchain applications in Norway's offshore industry showed that the "intention to work more efficiently using modern information technology opportunities" (Gausdal et al. 2018) is one of the drivers of Blockchain in practice (Gausdal et al. 2018). A change from for instance an entirely paper-based to a Blockchain-based process will require companies to rebuild processes. These companies will have to experiment with the technology and rethink each step in order to achieve continuity, both of which are primary drivers of digitalization generally (von See 2019, pp. 96, 139–141). While this process can be complicated, it will also be necessary to maintain a company's competitive position. Thus:

Observation 15

The intention to use Blockchain solutions for SC&L drives the digital transformation of a company's processes, because Blockchain solutions require a continual, digitally connected data trail.

5.2.6.3 Blockchain Solutions Give Rise to New Gatekeepers

Organizing Blockchain solutions for administrative and technical aspects does not happen organically; companies that offer solutions in the Blockchain space seek to attract customers. One expert explained:

> *Because brands sometimes are approached by many different companies that offer Blockchain services. […] And they want to […] stick with one vendor, for example IBM, who, sort of like a shepherd, leads the sheep toward one goal.*
>
> *expert #20, logistics service provider*

Another learning the experts shared was that these technology companies are beginning to dominate the deployed Blockchain solutions. These software vendors become involved in the decisions regarding the design of the processes as part of the software's further development. While trying to bypass intermediaries and centralized platforms, the companies are now becoming dependent on single software vendors. A few experts critically noted that this dependency causes problems:

> *This is just not decentralized, this is still a centralized governing structure, and in the end you are dependent on one provider again*
>
> *expert #21, manufacturer*

> *If a large service provider says: "We are building a private Blockchain, or we are building a network on Blockchain technology." It is always put so nicely: "We offer it to our customers for use." I wonder where the advantage over a distributed database is now if you install a middleman like this service provider?*
>
> *expert #6, authority*

In short, big tech companies are playing a key role in the development of Blockchain solutions. This role creates a centralist dependency that may be unsustainable in the long run for the participating companies.

This conclusion mostly affected *endeavorists* because companies, because they favor having a technology provider that ensures that the software works and that is available for support. However, studying the first published cases, these companies will likely carefully review the terms of governance and the alternative software

providers before committing to a solution for productive operations (Jabbar et al. 2018; Tönnissen et al. 2020). *Hypsters* are befuddled by this observation. If they are aware of it, it fuels their technology skepticism instead. Similarly, *enthusiasts* are skeptical of the big tech companies, but solve this dilemma by either taking the leadership role themselves or avoiding the big tech companies as partners by building their own solutions.

There has been little discussion about the possible impacts of big tech companies on Blockchain, although many pilot studies and use cases have worked with them (Saberi et al. 2018; Tönnissen et al. 2020; Casino et al. 2019). However, a few publications have discussed possible anti-trust action against big tech companies such as IBM, Facebook, Uber, or Microsoft from a general or a law perspective (Carrier 2020; Foroohar 2019; Schrepel 2020). In light of past developments and the digital dominance of these big technology companies, it is worth critically discussing their interests in Blockchain solutions (Barwise et al. 2018, pp. 26, 43). Notably, IBM with Maersk has built a case that faces virtually no competition. In the Walmart fresh leafy greens suppliers case, the IBM solution was practically forced on Walmart's suppliers (Groenfeldt 2017; Jabbar et al. 2018; Walmart Inc. 2018; Corkery et al. 2018). This position is not limited to IBM; for instance, R3 partners with Microsoft for its MarcoPolo trade platform (Ali 2017; del Castillo 2016). Thus:

Observation 16

Blockchain solutions for SC&L can be negatively influenced by the power concentration and dominance of single Blockchain technology providers.

5.2.6.4 Blockchain Is One of Many Options

The takeaway for companies from their first Blockchain explorations, according to the experts, is that Blockchain is not suitable for every cross-company use case or every logistics process.

> *Today, you are in a situation where, if you only have a hammer, everything looks like a nail. And that's exactly the same with Blockchain. Everyone wants to use Blockchain, but actually, if you only need part of it, only the database, you don't need smart contracts. But today, people want to use Blockchain.*
>
> *expert #23, IT solutions provider*

> *In at least half of the use cases, you ask yourself: Does it have to be Blockchain? Or are we doing this because it is possible?*
>
> *expert #2, consulting company*

There are alternative solutions to Blockchain, and it is necessary to consider whether centralized platform solutions, synchronized databases, or even simple decentralized network storage could also solve the problem. The experts believed that, in some cases, Blockchain may instead be an addon to existing infrastructure:

> *Blockchain is a good option for very specific use cases. In the future, IT will add a combination of different technologies, and the current central, cloud-based solutions will continue to exist, but they will be combined, for specific requirements, with Blockchains.*
>
> *expert #1, IT solutions provider*

> *I think a lot of large companies are starting to see it more as an internal within the conglomerate's system that would help them manage their own suppliers internally, rather than being like the Maersk case, wanting to unite competitors in a broader market.*
>
> *expert #24, research*

Overall, the learning is that companies sometimes try to implement Blockchain without a technical reason for doing so. There is not always a need for trustless, decentral transactions and smart contracts, and the technology's suitability is often not interrogated early enough in the development process.

Enthusiasts have internalized this learning. These companies will concentrate on fulfilling the Blockchain requirements because they are well acquainted with the technology. *Endeavorists* focus more on solving one or more problems in their company and are therefore more critical of these technologically driven decisions:

> *My recommendation would be to think about what I want to solve. […] Work out the use case as clearly as possible and then think about whether Blockchain could be an application for this and look at the existing technical approaches.*
>
> *expert #8, logistics service provider*

Endeavorists can benefit most from this learning, as they may realize that a legal agreement, along with an alternative technological approach, may be more straightforward. For *hypsters*, this is not relevant, as they have not yet decided on a technology. "The choice between a centralized database and a permissionless or permissioned Blockchain is not trivial," Wüst et al. (2018) noted, yet they also pointed out that, in many cases, using a centralized database will suffice (Wüst et al. 2018). Indeed, the hype around Blockchain leads to technology-driven rather than use case-driven approaches (Casino et al. 2019; Pedersen et al. 2019). Companies are not considering that individual features of Blockchain are readily available in other IT solutions at much lower cost. However, there are valid cases for SC&L that are better off using a Blockchain solution and should do so. Thus:

Observation 17

Blockchain solutions for SC&L are often considered or developed without investigating alternative technical approaches for the specific use case.

5.3 Preliminary Conclusions

In this section, the implications for research and management are derived, also outlining limitations and possible next steps to overcoming them. In Chapter 6 on page 153, the findings will be integrated with the results from Chapter 3 on page 21 and Chapter 4 on page 61.

5.3.1 Implications for Research

The results and discussion also revealed implications for research and theory. Overall, contributions regarding theory-building for Blockchain in SC&L are limited. However, for further research, a holistic view is required to embed Blockchain in a broader context of SC&L research. Especially three aspects should be considered: (1) economic models for Blockchain ecosystem solutions, (2) different governance models for Blockchain solutions, and (3) the relationship between Blockchain and the digital shift.

First, as outlined in the analysis, designing Blockchain solutions around ecosystems could hold additional business advantages for the members, strengthening their long-term market power. The upstream and downstream supply chain members could use the Blockchain solution to provide the members with additional services or completely independent business ventures. There has been very little research into building such ecosystems, including incentivization mechanisms, or existing theories or models. Nandi et al. (2020) took the theoretical perspective of the resource-based view (RBV) for Blockchain solutions in SC&L, while Schmidt et al. (2019) used transaction cost theory. Beyond the RBV and the transaction cost theory, Treiblmaier (2018) made first remarks considering principal-agent theory (PAT) and network theory. However, the discussion is far from concluded: All the authors have stated that their approaches used the early literature about Blockchain in SC&L as a basis, and did not consider the ecosystems that Blockchain solutions could create. Investigations into economic models for these ecosystems will be required, especially outlining ways to develop new competitive advantages or maintain existing competitiveness. In this context, it will be beneficial to research designs for economic incentivization models for these ecosystems that are inclusive and attractive for companies – inclusive so as to accommodate actors' different abilities, especially in worldwide supply chains and attractive because first trials, such as Walmart's solution for leafy green vegetables, have been introduced using

market power, instead of attracting companies through economic incentives. Market power also strongly influences organizational constructs and the governance structures therein. The design of governance mechanisms is an ongoing discussion (Lumineau et al. 2021; Beck et al. 2018; Lacity 2018). Blockchain governance has many paradoxical aspects. On the one hand, companies would like to steer, make centralized decisions quickly, and have an addressable, accountable entity. On the other hand, the Blockchain solution should remain as easy as possible to access without complicated administrative or technical processes to welcome new participants with open arms. New research could empower these companies by providing models for governance and the necessary decision-making. While the more recent studies have focused on Blockchain governance generally (Lumineau et al. 2021), more SC&L-focused research could incorporate the different interests of upstream and downstream supply chain participants and likely power imbalances therein.

Second, researchers should address the role of governments in Blockchain governance beyond finance. Their role is rarely addressed, even though, in SC&L practice, the involvement of customs and regulatory authorities is to be expected and may have far-reaching implications. These aspects pertain to big tech companies: While their dominance is generally discussed, there has been little research into the implications of their involvement in Blockchain solutions for SC&L (Barwise et al. 2018; Jabbar et al. 2018). An extension of the existing approaches could yield a more in-depth understanding of these governance structures' design and how to balance different powerful entities.

Third, Blockchain's influence on the digital shift should be explored further. The results showed that, owing to its requirements for a digital data trail, Blockchain can be used as a lever to enforce or promote the digital shift in a supply chain. However, to what extent it can be applied in practice and how large its impact is remain open questions. Further, there is a lack of understanding of the topics that accompany digitalization: The ideal approach to such a digital shift is not well defined. While it seems easy to conclude that all processes need digital recording, it can be hard to organize such a process. The same applies to the decisions on which data should be shared. While there is some understanding regarding this aspect, these contributions typically discuss the digital shift in SC&L generally (Barreto et al. 2017; Winkelhaus et al. 2020; Kersten et al. 2019; von See 2019), often in relationship with *Industry 4.0,* rather than Blockchain technology's specific impacts.

5.3.2 Implications for Management

These observations also allow for conclusions for management practice. The adoption of Blockchain solutions for supply chains and logistics companies will require managers to address barriers, choose adoption paths, and learn from the conclusions companies have already drawn. Companies should keep five major implications in mind during this process: (1) choosing the right use case, (2) building their solution or application for ecosystems, (3) embracing the technology's existing barriers, (4) being ready to share more data, and (5) moving to a fully digitalized environment.

A large share of the interviewees noted immense hype around Blockchain technology. Thus, companies may feel pressured to enter the Blockchain space quickly. However, as outlined, companies such as *hypsters, endeavorists,* or *enthusiasts* have different resources and abilities available to study Blockchain in SC&L.

First, companies should identify a relevant use case that would benefit and fit their business model strategically or operatively (8 in Table 5.2 on the next page). Blockchain technology can have benefits, but a partial solution using readily available enterprise-level software may be sufficient for many situations. The interviewees from *enthusiast* companies noted that they rushed to test Blockchain without a well-defined use case or trying to use existing software to fulfill the addressed use cases. The analysis showed that a well-established use case allows one to select an appropriate adoption path and business model. While it is possible to design and establish Blockchain solutions as closed-source, in-house projects, these solutions will struggle to gain trust and traction among business partners. Project managers should include the core partners and participants early on, also from outside the company. They form the seed of the later user base, and their feedback will improve early versions of the product.

Second, a powerful Blockchain solution is an ecosystem that grows into a network of services and applications beyond the focal supply chain or focal logistics application (9 in Table 5.2 on the facing page). Companies should seek to build a solution that fulfills their own need but also allows for such an ecosystem to grow. The partners of the focal supply chain will likely benefit from the opportunities that can emerge from such an ecosystem. On the one hand, they could be offered additional services around the focal supply chain, for instance, data analytics or data-driven, alternative transportation modes. On the other hand, they could use this infrastructure for their own business offers to customers beyond the focal supply chain. Currently, no such

Table 5.2: Embedding the Implications (1-12) for Management in a Process Model for Business Integration by Nedbal (2013) (cont. from Table 4.4 on page 75).

Process phase	Scope: Company-internal	Scope: With supply chain partners
Assessment	**5** Preparing for the inclusion of Blockchain solutions in operations	**1** Testing use cases identified by researchers
	6 Educating employees on Blockchain solutions	
Analysis	**7** Addressing company-internal barriers	**2** Reinforcing existing setups may be possible with Blockchain solutions
	8 Choosing the most fitting use case	
	12 Digitalizing processes to take part in Blockchain solutions	**9** Building a Blockchain solution as an ecosystem beyond the focal supply chain
Design		**11** Preparing to share data with the supply chain partners
Realization		**10** Embracing the existing barriers of the technology
Operation		**4** Needing supply chain partners to work together to achieve the benefits of Blockchain
		3 Increasing supply chain visibility with Blockchain

Implication relevant to:

- one phase and one scope
- one phase and both scopes
- more than one phase and both scopes
- more than one phase and one scope

solutions exist, but they can be observed in related fields such as cryptocurrency tokens or centrally organized social networks. Like social networks, the solutions for SC&L that grow into large ecosystems will have more market power and will therefore attract more participants. Centering business models around selling access to this infrastructure will be counterproductive to these ecosystems' growth. Thus, companies should implement governance mechanisms in the solution that are not counterproductive to this growth. If the infrastructure is too autocratic, it alienates prospective participants. Some experts also warned that too many stakeholders may take too long to come to a decision. The governance type should be specific to the application and the overall solution. Involving the users early on can avoid misunderstandings. Using their feedback can help one to implement appropriate decision-making and governance mechanisms, particularly for issues beyond the technology, such as integrating ways to mediate conflicts or reach settlements.

Third, companies should embrace Blockchain solutions' shortcomings (10 in Table 5.2 on the previous page). The existing implementations still have problems regarding the technology as well as regulatory questions. Companies designing or using a Blockchain solution should define the minimal dataset early on and should involve their legal and business analytics departments in assessing the positive and the negative implications. While management boards that are very protective of their data can still find it hard to move forward with a Blockchain solution, a steep increase in data exchange in SC&L can be expected regardless of whether or not a Blockchain solution is used. A careful review of the data already being shared with external partners and platforms can help to assess the possible impacts. After all, companies may be better off with a Blockchain solution offering equal access to all participants than exclusively giving their data to a third party.

Fourth, companies should prepare to share data with their whole supply chain for mutual profit, but also for mutual data analysis (11 in Table 5.2 on the preceding page). Companies designing or using a Blockchain solution have to define the minimal set of data early on and involve their legal and business analytics departments to assess positive and negative implications. Management boards very protective of their data can still find it challenging to move forward with a Blockchain solution. However, a steep increase in data exchange in SC&L can be expected regardless of whether a Blockchain solution is used. A careful review of data already being shared with external partners and platforms can help to assess the possible impacts. After all, companies may be better off with a Blockchain solution offering equal access to all participants than exclusively giving their data to a third party.

Fifth, companies should digitalize processes (12 in Table 5.2 on page 145). The data for Blockchain must be accessible in digital form. One key learning that stands out in the analysis is that, independent of the part of the world or a company's size, fully digital data streams on goods are not standard. Experts repeatedly stressed that unstructured, informal paper, e-mail, or phone-based communication is still all too familiar in SC&L processes. In the Blockchain world, resistance against digitalization is futile. Companies should move to a fully digital data trail before they can partake in a Blockchain solution. Many experts thought this could be beneficial, regardless of whether the company ends up using a Blockchain or an alternative solution. Thus, the preparation for Blockchain can be a tool to enforce the digital shift, not only owing to data access and process redesign, but also questioning current development techniques. To date, development procedures will help to account for the frequent changes required by Blockchain implementations and to enable rapid feature testing.

5.3.3 Limitations and Opportunities for Further Research

The approach and topic discussed in this study have limitations that should be considered when evaluating the results. Grounded Theory allows researchers to uncover interactions and provides explanations substantiated from data (Charmaz 2014, pp. 234–241; Suddaby 2006). In the results section, these explanations were outlined as distinct motivations, adoption paths, barriers, and learnings. However, while the study explored and uncovered these interactions, Grounded Theory is not a method for testing (Charmaz 2014, p. 18; Suddaby 2006); the observations were therefore not statistically tested.

While the sample, obtained through a theoretical sampling approach, provided valuable insights, it is not representative of an underlying population. Thus, company-specific or use case-specific circumstances should be kept in mind during application or further research. Also, interviewees may have withheld information owing to the public's strong interest in Blockchain. Experts who work with cryptocurrency tokens were cautious of the consequences their statements may have on the very volatile markets, possibly shortening some of their statements.

The data collection timing should also be considered: The Blockchain field is widely discussed in public and has rapid development cycles. Especially concerning the applicability of the identified technological barriers, it can be expected that technological improvements will eventually mitigate some of them. On the other

hand, the public pressure may force companies to adopt Blockchain solutions despite organizational barriers.

The results also provide opportunities for further research. The presented observation (see Table 5.3 on the facing page) should be further investigated using qualitative and quantitative inquiry. Foremost, quantitative testing could offer statistical proof and insights regarding differences among stakeholder groups.

Observations 1 and 2 warrant a thorough, qualitative investigation to describe optimal managerial procedures for implementing them in practice. Quantitative testing could shed light on the differences between stakeholders regarding governance and privileges in the organizational construct.

Observations 3 to 5 require followup research on Blockchain solutions' design. Currently, there seems to be no research into the optimal Blockchain solutions design and respective ecosystems for SC&L. An in-depth approach could address, for instance, what attracts participating users and service providers, how to design network economics, and how to ensure the success of Blockchain ecosystems for SC&L.

Observations 6, 11, 13, and 17 outlined the need for further case study research and applied science projects regarding business models for Blockchain in SC&L. There were few independently researched reports from practice or that focus on particular cases. Further, there have been few contributions regarding SMEs' specific needs.

Observation 7 addresses legislative barriers. A qualitative investigation of applications could expose these pitfalls. More importantly, a quantitative assessment of these legal problems' severity could persuade policymakers to address this barrier.

Technological advancement of Blockchain implementations will allow for additional research opportunities: Observations 9, 10, and 12 mainly need to be addressed in the technological concepts, but could likely benefit from a detailed investigation of possible applications and existing shortcomings, for instance of labels or during handling processes.

Almost every expert addressed the need to share data (observation 14), possibly with additional or new partners. It remains unclear to what extent data-sharing through Blockchain positively or negatively impacts a business and the supply chain. The setting is very particular and, so far, no data from case studies exist. Further, while more transparency is typically considered an improvement, it could also lead to unwanted disclosures of private information. The implication of increased

transparency on the companies' privacy and employees remain under-researched. Supply chain research could partner with experts from system security research to identify possible attack vectors.

Digital transformation remains a relevant topic in the logistics industry, even beyond Blockchain. As observation 15 outlines, Blockchain can be a lever to drive this digital shift. Optimal methods on how to apply this lever remain to be discovered.

Finally, the investigation on Blockchain solutions in SC&L also revealed that there are new gatekeepers, namely big tech companies, who are marketing their proprietary solutions (observation 16). How this influences companies' decisions and whether there are parallels to existing platforms remain to be studied.

Table 5.3: Overview over the Observations Presented during the Analysis

#	Observation	see
1	Blockchain solutions for SC&L require an efficient organizational construct that allows for leadership and ideally represents the entire supply chain.	p. 100
2	The governance mechanism used in Blockchain solutions for SC&L must allow for the creation of data standards, must solve conflicts, and must maintain an openness to adding new companies.	p. 102
3	Blockchain solutions for SC&L require market power to be established and to acquire users.	p. 105
4	Blockchain solutions for SC&L require the anticipation of the supply chain actors' needs already during the development.	p. 107
5	Blockchain solutions for SC&L should be designed to allow the growth of an ecosystem around the focal supply chain to allow the supply chain members to benefit by creating additional business models on the same solution.	p. 110
6	Business models for SC&L should use the Blockchain implementations as an infrastructure or an operating system, not as its integral part.	p. 110

continued on the next page

(Cont.) Table 5.3: Overview over the Observations

#	Observation	see
7	Unclear legislation hampers Blockchain solutions for SC&L.	p. 112
8	Companies currently consider Blockchain solutions to be not mature enough for productive use for SC&L.	p. 114
9	To be used broadly in practice, Blockchain solutions for SC&L require adaptable software frameworks that are capable of connecting to intra-company software systems.	p. 117
10	Association and identification of physical objects is a requirement for Blockchain solutions for SC&L to work. To fulfill this requirement, the methods used for this identification must be tamper-resistant, reliable, and inexpensive.	p. 120
11	The lack of sample use cases that include experience form practice make companies hesitant to adopt Blockchain.	p. 122
12	Blockchain solutions for SC&L may make companies prone to industrial espionage, as transaction data and metadata allows for the drawing of conclusions regarding their business.	p. 124
13	Some companies recognize that Blockchain solutions for SC&L pose a threat to their competitiveness.	p. 127
14a	Blockchain solutions for SC&L require companies to share data with partners they currently do not need to share data with.	p. 133
14b	Blockchain solutions for SC&L should limit the data stored on-chain to the minimum required in order to secure all the partners' trust.	p. 133
15	The intention to use Blockchain solutions for SC&L drives the digital transformation of a company's processes, because Blockchain solutions require a continual, digitally connected data trail.	p. 137
16	Blockchain solutions for SC&L can be negatively influenced by the power concentration and dominance of single Blockchain technology providers.	p. 139

continued on the next page

(Cont.) Table 5.3: Overview over the Observations

#	Observation	see
17	Blockchain solutions for SC&L are often considered or developed without investigating alternative technical approaches for the specific use case.	p. 141

Chapter 6

Conclusion and Outlook

"Remember when, on the Internet, nobody knew who you were?" Hafeez responded in his 2015 cartoon to Steiner (1993), commenting on how easy it is to find people online (Hafeez 2015). Various technological approaches allow companies or individuals to identify, communicate, or track each other online. Similar technological approaches could improve cross-company, multitier data-sharing and, above all, the information flow and performance of SC&L functions. Yet, in practice, these data are hardly available across the supply chain, despite existing efforts such as cloud solutions or EDI. This lack leaves end-customers as well as downstream and upstream companies guessing. Gaining the public spotlight as the operating system of Bitcoin and Ethereum, it became clear that Blockchain solutions could be another way to tackle this problem. The tamper-resistant, decentralized, and distributed ledger could serve as an application basis for SC&L by providing a trusted and universal database of transaction records regarding a material flow.

The research objective of this thesis was to gain a better understanding of the Blockchain adoption process and its implications for supply chain management and logistics. The novelty of the topic required addressing it from different perspectives. Three methodological approaches were chosen, each addressing a particular research aspect and question. The study to answer research question 1 examined the scientific literature regarding the adoption potentials of Blockchain in SC&L. The analysis of 135 articles shed light on the use cases that studies have described for Blockchain technology and which methods they have used to identify these. The investigation of research question 2, outlined how practitioners viewed the applicability of Blockchain in SC&L. A survey with 151 participants yielded insights into opportunities, barriers, and first application use cases. The main study addressed research question 3: The intention was to explore how have companies adopted

Blockchain solutions in SC&L. Qualitative data collected from 24 expert interviews utilizing a theoretical sampling strategy were used for a Grounded Theory method. The recorded statements allowed for extensive insights into adoption paths chosen by companies, barriers they face, and their learnings. The conclusions that can be drawn from these three studies will now be examined in-depth. The key findings for each research question and an overall outlook will be presented.

Research Question 1

RQ1: How has Blockchain adoption in SC&L been discussed in the literature?

RQ1a: Which use cases have been investigated for Blockchain in SC&L, for which industries, and what benefits are expected?

RQ1b: Which research approaches have been used to investigate Blockchain use in the SC&L sector?

To investigate RQ1 and fully explain the current state of the literature, two more research questions (RQ1a and RQ1b) were addressed.

Regarding **RQ1a**, the literature review yielded eight major and nine additional use cases. Most contributors described the utilization of Blockchain technology to maintain data integrity across several actors. Integrity was the enabler for six out of eight use cases, namely tracing goods, documenting process steps, anti-counterfeiting approaches, transparent and decentralized access, and providing IoT infrastructure. The two other major use cases addressed performance analysis and the improvement of communication security. Most of the investigated use cases focused on the production and distribution of food or pharmaceutical products. These supply chains have a unique need for tracing, but also have multiple separate actors that use disjunctive IT systems to store data about the products. A practical implementation of a Blockchain solution for these products' SC&L functions could improve these supply chains by providing an overarching dataset.

Investigating **RQ1b** showed that conceptual work and test runs were the approaches that were used most often in the observed period. Thus, one conclusion is that the research community is actively working on Blockchain solutions for practice. However, the lack of empirical work and the limited practical feedback on the implementation work also cast doubts on these concepts' feasibility in practice. Of the 58 conceptual contributors, 31 did not focus on a specific industry, only on

the possibilities for SC&L generally. Among the limited number of contributions that used an empirical method, 7 of 14 focused on a specific industry, while the others focused on industry-independent use cases, which were, also limited by very specific circumstances. A small number of contributors focused on reviewing the existing literature, making considerations to theory or outlining technological aspects. Future research approaches require further extension, not only of the empirical basis but also regarding theory-building.

Overall, regarding **RQ1**, it can be concluded from the literature research that, with some limitations, the researchers and authors of most of the articles expect that the SC&L sector will adopt Blockchain solutions. The results showed that the most addressed use cases were close to the fundamental SC&L functions, allowing the conclusion that adoption concepts will focus on these. While most of the work was conceptual, the insights from the specialized use cases showed that the design of Blockchain adoption concepts could include possibilities for logistics companies to offer value-added services.

Key Findings for Research Question 1

- Conceptual work has described use cases for Blockchain in SC&L. There were eight major use cases, with tracing goods, providing documentation, preventing counterfeiting, and transparency of information standing out.
- Most outlined use cases addressed a fundamental requirement of SC&L: The short-term availability of reliable information.
- The most addressed industries were the food and the pharmaceuticals. In both, the traceability of goods, handlers, and processors are key requirements.
- There has been little empirical work. While Blockchain adoption seems to be a clear goal, learnings from de facto use cases and the shaping of possible adoption paths will require new contributions.

Research Question 2

RQ2: How have practitioners perceived Blockchain's benefits and prospects in SC&L?

Insights concerning research question 2 revealed possible benefits of and barriers to Blockchain use cases and the industries' stances toward Blockchain solutions. Four use case examples were introduced to investigate suitable Blockchain applications: (1) ease of paperwork processing, (2) identification of counterfeit products, (3) origins tracing, and (4) operating IoT devices. In a survey, 151 participants rated the four Blockchain solution use case examples regarding benefits for SC&L and their adoption likelihood. The perceived benefits of all four use case examples were high allowing the conclusion that Blockchain technology is suitable for SC&L. While there were only slight differences between the use case ratings long-term, practical experiences with Blockchain in SC&L were limited at the time of data collection. Still, a considerable number of companies from the sample are already investigating use cases or have already implement first Blockchain solutions. Already, more than 57% of the companies in the sample have actively considered Blockchain solutions for their use cases.

The participants consider Blockchain solutions to strongly impact on the logistics industry. They do not believe this impact to be radically disruptive – as some authors – such as Tapscott et al. (2016) or Swan (2015) – predicted. The participants expect that Blockchain will be beneficial for the various parties involved in SC&L, especially for the technology and the logistics service providers.

Thus, concerning **RQ2**, it can be concluded that practitioners evaluated Blockchain as applicable in SC&L. Some skepticism remains: the middle managers were less enthusiastic about Blockchain solutions in SC&L. Further, numerous barriers still remain to be addressed, especially the regulatory questions and the best ways to collaborate with new partners along the supply chain.

Key Findings for Research Question 2

- Blockchain solutions for SC&L will bring a considerable change but will not be radically disruptive.
- Blockchain in SC&L is here to stay. The practitioners expect the application of Blockchain technology throughout the industry in the future.
- Regulatory uncertainties regarding the technology's use and legal validity and the need to collaborate with new partners along the supply chain remain barriers.
- Logistics service providers, senders, receivers, and technology providers are likely to benefit most from Blockchain technology.

Research Question 3

RQ3: How have companies been adopting Blockchain in SC&L?

RQ3a: How have companies familiarized themselves with Blockchain adoption in SC&L?

RQ3b: Which factors are preventing companies from adopting Blockchain in SC&L?

RQ3c: Which conclusions do companies draw from the first adoption steps?

Research question 3 has many aspects that must be accounted for. Thus, three additional, more specific research questions (RQ3a, RQ3b, and RQ3c) that address individual aspects were derived.

Investigating **RQ3a** revealed two main adoption paths: An organizational path and a practical path. The former describes the administrative aspects that companies address for the adoption of a Blockchain solution. The results showed that this includes establishing an organizational construct (e.g., a consortium or cooperative), defining governance mechanisms, and identifying ways to establish market relevance. For the latter path, practical adoption requires early trials and a business

models design that considers Blockchain solutions as an ecosystem beyond the focal supply chain.

Taking the first steps toward adopting a Blockchain solution, the companies face barriers that prevent them from integrating and even testing a Blockchain solution. The analysis concerning **RQ3b** revealed two barrier types: External ones that a company can hardly influence, and internal ones, driven by its strategy. The external barriers mostly stem from the remaining technical limitations of the underlying Blockchain implementations. The remaining regulatory questions are an additional external barrier, mainly because the requirements across countries can differ. Internally, companies struggle with the lack of use cases that can serve as a blueprint and with possible negative implications of using Blockchain solutions. These negative implications include the possibility of industrial espionage or competitive intelligence, and threats to the company's competitiveness owing to additional transparency.

The analysis concerning **RQ3c** yielded four learnings that influenced the adoption paths: The key learning was that benefitting from a Blockchain solution requires digital transformation. Especially the need to provide digital data for process steps is something some companies struggle with, because it requires them to rework their processes. The second learning is the necessity to share data with more partners than in conventional solutions. While this is easy for companies working in the greenfield, existing businesses can find the additional exposure tough to factor into their adoption approach. Further, the analysis showed that companies fear the rise of new gatekeeping companies that, similar to social media network operators, use their technological superiority to dominate Blockchain solutions. Finally, companies are realizing that the use case for a Blockchain solution must be well defined, because more mature software often exists that could also fulfill the requirements.

Overall, regarding **RQ3**, the companies' approaches varied owing to different initial considerations, perceptions of barriers, and abilities. The descriptions of the three ideal company types (*hypsters*, *endeavorists*, and *enthusiasts*) of companies reflect these differences. The analysis showed that companies can alter their adoption paths and can consider both barriers and learnings. However, not all companies reach the conclusion to use or test a Blockchain solution in practice – unsurprisingly, because the results also showed that Blockchain solutions are a new technology concept that still needs to grow. Many experts considered the implementations too immature for a productive environment in a company. Nonetheless, de facto real-world applications are being developed and are slowly growing into larger

ecosystems. The development of a Blockchain application will require significant manual software development and the anticipation of some barriers already during the design phase.

Key Findings for Research Question 3

- Blockchain solutions require an organizational construct that ensures market relevance, and that creates and executes governance tasks.
- Practical dissemination of Blockchain solutions requires de facto trials and designing for ecosystem use from the outset.
- External barriers to Blockchain adoption include regulatory uncertainties, technical limitations, a lack of off-the-shelf software solutions, and challenges associating physical objects.
- Internal barriers to Blockchain adoption include a lack of sample use cases to learn from, the fear of industrial espionage, or new kinds of competition.
- The digitalization of processes is a key prerequisite to participating in Blockchain solutions.
- The use case for the Blockchain solution should be well-researched because ready-to-use software exists for many solutions.

The research process overall also showed the rapid development of Blockchain implementations and applications. In parallel to this thesis, the Blockchain space for SC&L has progressed enormously; the presented results are a snapshot of huge, ongoing change for information technologies in SC&L. In the long run, Blockchain solutions could develop into a massive infrastructure tool that allows companies to drive efficiency by aligning supply chain partners worldwide. In concert, the Blockchain solutions could become a worldwide multi-supply chain ecosystem, allowing companies to offer a range of value-added services, for instance, providing identities, certification, or anti-counterfeiting solutions.

The understanding that Blockchain will shape SC&L in the future emphasizes the need to further explore this space. In the coming years, companies will require more concepts tailored to their sectors. On the one hand, this will make it necessary

to collect more empirical data that document established companies' insights and practical experiences as well as their ways toward using a Blockchain solution. On the other hand, this also requires solutions for the existing barriers as well as general strategies for supply chain-wide Blockchain solutions deployment. These deployment strategies are especially interesting to derive, because they will need to include entire networks and considerations toward creating and governing large ecosystems.

First large-scale, real-life projects can be observed today: Walmart Canada claimed that using Blockchain together with IoT devices has eliminated most of its transport-related disputes (Shein 2020). The coffeehouse chain Starbucks is working on a Blockchain solution that allows farmers and their customers to trace the coffee beans from the bush to the cup (Almeida 2020). Practical steps regarding the digitalization of document signatures can also be observed: The United States Postal Service has patented a Blockchain-based identity system that strengthens mail-in voting procedures (Goswami et al. 2020). There are also promising startups in the SC&L sector – for instance, OURZ, which aims to provide a generic Blockchain solution as a tracing platform for food production companies, or modum.io, which provides a temperature sensor for CEP shipments that uses a Blockchain to store the readings. Time will tell whether these solutions will prove successful.

The long-term vision for Blockchain solutions in SC&L has to be a universally accessible ledger of genuine, unalterable records for the origin, processing, and handling history of materials and goods open to end-customers and companies. In a perfect world, end-customers can trace an individual avocado back to its tree, including verified identities and certifications for producers, logistics services, and merchants. Suppliers, distributors, and other companies along the material flow may use these data for their operations, not only for optimization but also for record-keeping, auditing, and identification. In this respect, Blockchain solutions are becoming a strategic tool with an additional normative effect toward data standards: digitalization across the whole supply chain. Ideally, to achieve this, end-customers and companies could choose from a pool of competing, Blockchain implementation-independent software applications. End-customers could use this software access to the Blockchain records to identify organic foods, carbon dioxide footprints, or problematic ingredients. Likewise, companies can connect their own tools to gain insights into the origins chains of their raw materials, identify hazardous substances, track delays, or recognize optimization potentials. Thus, they can ensure that the minerals they use are not mined using child labor, or that no material additives are used that may pose health risks. Such universal access to

Blockchain can also benefit society. For instance, recycling companies could have better information about the materials in discarded products, authorities could follow up on food contaminations, and NGOs could verify sustainability claims. Compared to centrally organized solutions, Blockchain solutions can be designed and operated without the influence of large service providers or the need for a trusted third party. All participants can always verify all transactions themselves and can therefore be sure of the history's immutability.

Blockchain solutions may become a tool for society to hold companies responsible for the whole lifecycle of a product, record activities by government authorities, and provide a fraud-proof infrastructure. Considering the Paris Agreement on Climate Change and the European Green Deal, Blockchain solutions for supply chain management and logistics could serve as a cornerstone creating a data basis for sustainable development. Policymakers could create legislation requiring the use of a universally accessible Blockchain solution, for instance, as proof regarding supply chain laws or supply chain emissions. Such an open system could result in ecosystems and new markets for innovative SMEs and startups that are independent of the centralized solutions of the IT industry dinosaurs.

Bibliography

A. T. Kearney, ed. (June 23, 2020). *CSCMP's Annual State of Logistics Report*. Lombard, IL

Abelseth, Brian (2018). "Blockchain Tracking and Cannabis Regulation. Developing a permissioned blockchain network to track Canada's cannabis supply chain." In: *Dalhousie Journal of Interdisciplinary Management* 14

Abeyratne, Saveen A. and Radmehr P. Monfared (2016). "Blockchain ready manufacturing supply chain using distributed ledger." In: *International Journal of Research in Engineering and Technology* 05.09. DOI: 10.15623/ijret.2016.0509001

Agrawal, Tarun Kumar, Ajay Sharma, and Vijay Kumar (2018). "Blockchain-Based Secured Traceability System for Textile and Clothing Supply Chain." In: *Artificial Intelligence for Fashion Industry in the Big Data Era*. Ed. by Sébastien Thomassey and Xianyi Zeng. Vol. 05. Singapore: Springer, pp. 197–208. DOI: 10.1007/978-981-13-0080-6_10

Ali, Kashif (2017). *R3 on Azure: Strengthening our partnership*. Microsoft. URL: https://azure.microsoft.com/es-mx/blog/r3-on-azure-strengthening-our-partnership/

Allison, Ian (Mar. 8, 2017). "Maersk and IBM Want 10 Million Shipping Containers on the Global Supply Blockchain by Year-End." In: *International Business Times*

Almeida, Isis (Aug. 25, 2020). "Starbucks Clients Can Now Trace Their Coffee, And So Can Farmers." In: *Bloomberg*

Alzahrani, Naif and Nirupama Bulusu (2018). "Block-Supply Chain." In: *CRYBLOCK '18. Proceedings of the 1st Workshop on Cryptocurrencies and Blockchains for Distributed Systems: June 15, 2018, Munich, Germany*. International Conference on Mobile Systems, Applications, and Services. New York City, NY: The Association for Computing Machinery, pp. 30–35. DOI: 10.1145/3211933.3211939

Apte, Shireesh and Nikolai Petrovsky (2016). "Will Blockchain Technology Revolutionize Excipient Supply Chain Management?" In: *Journal of Excipients and Food Chemicals* 7.3, pp. 76–78

Archa, Bithin Alangot, and Krishnashree Achuthan (2018). "Trace and Track: Enhanced Pharma Supply Chain Infrastructure to Prevent Fraud." In: *Ubiquitous Communications and Network Computing*. Ed. by Navin Kumar and Arpita Thakre. Vol. 218. 218. Cham: Springer, pp. 189–195. DOI: 10.1007/978-3-319-73423-1_17

Atzei, Nicola, Massimo Bartoletti, Tiziana Cimoli, Stefano Lande, and Roberto Zunino (2018). "SoK: Unraveling Bitcoin Smart Contracts." In: *Principles of Security and Trust*. Ed. by Lujo Bauer and Ralf Küsters. Vol. 10804. Lecture Notes in Computer Science. Cham: Springer, pp. 217–242. DOI: 10.1007/978-3-319-89722-6_9

Banerjee, Arnab (2018). "Blockchain Technology: Supply Chain Insights from ERP." In: *Blockchain technology. Platforms, tools and use cases*. Ed. by Pethuru Raj and Ganesh Chandra Deka. Vol. 111. Advances in Computers volume 111. Cambridge, MA: Academic Press, pp. 69–98. DOI: 10.1016/bs.adcom.2018.03.007

Baralla, Gavina, Simona Ibba, Michele Marchesi, Roberto Tonelli, and Sebastiano Missineo (2019). "A Blockchain Based System to Ensure Transparency and Reliability in Food Supply Chain." In: *Euro-Par 2018: Parallel Processing Workshops*. Ed. by Gabriele Mencagli et al. Vol. 11339. Springer. Cham: Springer, pp. 379–391. DOI: 10.1007/978-3-030-10549-5_30

Barreto, L., A. Amaral, and T. Pereira (2017). "Industry 4.0 implications in logistics: an overview." In: *Procedia Manufacturing* 13, pp. 1245–1252. DOI: 10.1016/j.promfg.2017.09.045

Barwise, Patrick and Leo Watkins (2018). "The Evolution of Digital Dominance. How and Why We Got to GAFA." In: *Digital dominance. The power of Google, Amazon, Facebook, and Apple*. Ed. by Martin Moore and Damian Tambini. Oxford: Oxford University Press, pp. 21–49

Bastian, Hilda, Paul Glasziou, and Iain Chalmers (2010). "Seventy-five trials and eleven systematic reviews a day: how will we ever keep up?" In: *PLoS medicine* 7.9, e1000326. DOI: 10.1371/journal.pmed.1000326

Baumgardner, Jennifer (2014). "Williamsburg, Jahr null." In: *Hipster. Eine transatlantische Diskussion*. Ed. by Mark Greif, Kathleen Ross, Dayna Tortorici, and Heinrich Geiselberger. Deutsche Erstausgabe, 3. Auflage, Sonderdruck. Edition Suhrkamp. Berlin: Suhrkamp, pp. 81–89

Beck, Roman, Christoph Müller-Bloch, and John Leslie King (2018). "Governance in the Blockchain Economy: A Framework and Research Agenda." In: *Journal of the Association for Information Systems*, pp. 1020–1034. DOI: 10.17705/1jais.00518

Benton, Morgan C., N. M. Radziwill, A. W. Purritano, and C. J. Gerhart (2018). "Blockchain for Supply Chain: Improving Transparency and Efficiency Simultaneously." In: *Software Quality Professional* 20.3

Bermeo-Almeida, Oscar, Mario Cardenas-Rodriguez, Teresa Samaniego-Cobo, Enrique Ferruzola-Gómez, Roberto Cabezas-Cabezas, and William Bazán-Vera (2018). "Blockchain in agriculture: A systematic literature review." In: *Communications in Computer and Information Science* 883, pp. 44–56. DOI: 10.1007/978-3-030-00940-3_4

Bhattacharyya, Kuntal and Nathan Tanner Smith (2018). "Antecedents to the Success of Block Chain Technology Adoption in Manufacturing Supply Chains." In: *ACM International Conference Proceeding Series*, pp. 64–67. DOI: 10.1145/3278252.3278273

Biswas, Kamanashis, Vallipuram Muthukkumarasamy, and Tan Lum Wee (2017). "Blockchain Based Wine Supply Chain Traceability System." In: *Proceedings of the 2017 Future Technologies Conference (FTC)*. Ed. by The Science and Information (SAI) Organization. Vancouver, Canada

Blank, Steve (May 1, 2013). "Why the Lean Start-Up Changes Everything." In: *Harvard Business Review*, pp. 3–9

Boehm, Vanesco A. J., Jong Kim, and James Won-Ki Hong (2018). "Holistic Tracking of Products on the Blockchain Using NFC and Verified Users." In: *Information security applications. 18th international conference, WISA 2017, Jeju Island, Korea, August 24-26, 2017: revised selected papers*. Ed. by Brent Byung Hoon Kang and Taesoo Kim. Vol. 10763. Lecture Notes in Computer Science 10763. WISA and World International Conference on Information Security and Application. Cham: Springer, pp. 184–195. DOI: 10.1007/978-3-319-93563-8_16

Bowersox, Donald J., David J. Closs, Bixby M. Cooper, and John C. Bowersox (2020). *Supply Chain Logistics Management*. 5th ed. New York City, NY: McGraw-Hill

Buchholz, Udo et al. (2011). "German outbreak of Escherichia coli O104:H4 associated with sprouts." In: *The New England journal of medicine* 365.19, pp. 1763–1770. DOI: 10.1056/NEJMoa1106482. eprint: 22029753

Bumblauskas, Daniel, Arti Mann, Brett Dugan, and Jacy Rittmer (2020). "A blockchain use case in food distribution: Do you know where your food has been?" In: *International Journal of Information Management* 52, p. 102008. DOI: 10.1016/j.ijinfomgt.2019.09.004

Bundesvereinigung Logistik e. V. and Fraunhofer SCS, eds. (2019). *Umsatz der Logistikbranche in Deutschland von 1995 bis 2019*

Buterin, Vitalik (2013). *Ethereum White Paper: A next-generation smart contract and decentralized application platform*. URL: https://ethereum.org/whitepaper/

Buterin, Vitalik (Jan. 15, 2016). *Privacy on the Blockchain*. URL: https://blog.ethereum.org/2016/01/15/privacy-on-the-blockchain/

Buterin, Vitalik (Oct. 13, 2018). *To be clear, at this point I quite regret adopting the term "smart contracts". I should have called them something more boring and technical, perhaps something like "persistent scripts". [Tweet]*. URL: https://twitter.com/VitalikButerin/status/1051160932699770882

Büyüközkan, Gülçin and Fethullah Göçer (2018). "Digital Supply Chain: Literature review and a proposed framework for future research." In: *Computers in Industry* 97, pp. 157–177. DOI: 10.1016/j.compind.2018.02.010

Caro, Miguel Pincheira, Muhammad Salek Ali, Massimo Vecchio, and Raffaele Giaffreda (2018). "Blockchain-based traceability in Agri-Food supply chain management: A practical implementation." In: *2018 IoT Vertical and Topical Summit on Agriculture - Tuscany (IOT Tuscany)*. Piscataway, NJ: IEEE, pp. 1–4. DOI: 10.1109/IOT-TUSCANY.2018.8373021

Carrier, Michael A. (Jan. 14, 2020). "Big Tech, Antitrust, and Breakup." In: *Georgetown Journal of International Affairs*

Cartier, Laurent E., Saleem H. Ali, and Michael S. Krzemnicki (2018). "Blockchain, Chain of Custody and Trace Elements: An Overview of Tracking and Traceability Opportunities in the Gem Industry." In: *Journal of Gemmology* 36.3, pp. 212–227. DOI: 10.15506/JoG.2018.36.3.212

Casado-Vara, Roberto, Alfonso González-Briones, Javier Prieto, and Juan M. Corchado (2019). "Smart Contract for Monitoring and Control of Logistics Activities: Pharmaceutical Utilities Case Study." In: *International Joint Conference SOCO'18-CISIS'18-ICEUTE'18. San Sebastián, Spain, June 6-8, 2018 Proceedings*. Ed. by Manuel Graña, José Manuel López-Guede, Oier Etxaniz, Álvaro Herrero, José Antonio Sáez, Héctor Quintián, and Emilio Corchado. Vol. 771. Advances in Intelligent Systems and Computing 771. Cham: Springer, pp. 509–517. DOI: 10.1007/978-3-319-94120-2_49

Casey, Michael J. and Pindar Wong (Mar. 13, 2017). "Global Supply Chains Are About to Get Better, Thanks to Blockchain." In: *Harvard Business Review*

Casino, Fran, Thomas K. Dasaklis, and Constantinos Patsakis (2019). "A systematic literature review of blockchain-based applications: Current status, classification and open issues." In: *Telematics and Informatics* 36, pp. 55–81. DOI: 10.1016/j.tele.2018.11.006

Charmaz, Kathy (2014). *Constructing grounded theory*. 2nd ed. Introducing qualitative methods. Los Angeles et al.: SAGE

Chen, Si, Rui Shi, Zhuangyu Ren, Jiaqi Yan, Yani Shi, and Jinyu Zhang (2017). "A Blockchain-Based Supply Chain Quality Management Framework." In: *14th*

IEEE International Conference on E-Business Engineering. ICEBE 2017: including 13th Workshop on Service-Oriented Applications, Integration and Collaboration (SOAIC 207): 4-6 November 2017, Shanghai, China. Ed. by Omar Hussain. IEEE International Conference on E-Business Engineering et al. Piscataway, NJ: IEEE, pp. 172–176. DOI: 10.1109/ICEBE.2017.34

Chod, Jiri, Nikolaos Trichakis, Gerry Tsoukalas, Henry Aspegren, and Mark Weber (2018). "Blockchain and the Value of Operational Transparency for Supply Chain Finance." In: *SSRN Electronic Journal*. DOI: 10.2139/ssrn.3078945

Chopra, Sunil and Peter Meindl (2016). *Supply chain management. Strategy, planning, and operation*. 6th ed. Always learning. London: Pearson

Christidis, Konstantinos and Michael Devetsikiotis (2016). "Blockchains and Smart Contracts for the Internet of Things." In: *IEEE Access* 4, pp. 2292–2303. DOI: 10.1109/ACCESS.2016.2566339

Christopher, Martin (2016). *Logistics & supply chain management*. 5th ed. London: Pearson

Chu, Yang, John Ream, and David Schatsky (2016). *CFO Insights: Getting Smart About Smart Contracts*. Deloitte

Clark, Birgit and Ruth Burstall (2018). "Blockchain, IP and the pharma industry—how distributed ledger technologies can help secure the pharma supply chain." In: *Journal of Intellectual Property Law & Practice* 13.7, pp. 531–533. DOI: 10.1093/jiplp/jpy069

Cocco, Federica (Oct. 4, 2018). "Air France-KLM signs up blockchain partnership." In: *Financial Times*

CoinMarketCap.com (2021). *Today's Cryptocurrency Prices by Market Cap*

Cooper, Martha C., Douglas M. Lambert, and Janus D. Pagh (1997). "Supply Chain Management: More Than a New Name for Logistics." In: *The International Journal of Logistics Management* 8.1, pp. 1–14. DOI: 10.1108/09574099710805556

Corkery, Michael and Sapna Maheshwari (Mar. 13, 2020). "Is There Really a Toilet Paper Shortage?" In: *The New York Times*

Corkery, Michael and Nathaniel Popper (Sept. 24, 2018). "From Farm to Blockchain: Walmart Tracks Its Lettuce." In: *The New York Times*

Council of Supply Chain Management Professionals, ed. (2013). *CSCMP Supply Chain Management Terms and Glossary*

da Silva Barreto, Mayckel, Cristina Garcia-Vivar, and Sonia Silva Marcon (2018). "Methodological quality of Grounded Theory research with families living with chronic illness." In: *International Journal of Africa Nursing Sciences* 8, pp. 14–22. DOI: 10.1016/j.ijans.2018.01.001

Datta, Damayanti (2018). "Applications and Deterrents of Blockchain Technology in Logistics Management." In: *International Journal of Academic Research & Development (IJAR&D)*, pp. 29–34

DeCovny, Sherree (2017). *Experts Discuss Tackling Pharma Supply Chain Issues With Blockchain*. URL: http://www.nasdaq.com/article/experts-discuss-tackling-pharma-supply-chain-issues-with-blockchain-cm808938

del Castillo, Michael (2016). *R3 Blockchain Consortium Partners With Microsoft*. coindesk. URL: https://www.coindesk.com/consortium-of-global-banks-formalizes-partnership-with-microsoft

Denyer, David and David Tranfield (2011). "Producing a Systematic Review." In: *The Sage handbook of organizational research methods*. Ed. by David A. Buchanan and Alan Bryman. Thousand Oaks, CA: SAGE, pp. 671–689

Dickson, Ben (2016). *Blockchain Has the Potential to Revolutionize the Supply Chain*. URL: https://techcrunch.com/2016/11/24/blockchain-has-the-potential-to-revolutionize-the-supply-chain/

Dobrovnik, Mario, David Herold, Elmar Fürst, and Sebastian Kummer (2018). "Blockchain for and in Logistics: What to Adopt and Where to Start." In: *Logistics* 2.3, p. 18. DOI: 10.3390/logistics2030018

Dogecoin.com (2018). *Dogecoin*. Ed. by Shibetoshi Nakamoto and Jackson Palmer. URL: https://github.com/dogecoin/dogecoin/blob/master/README.md

Donadoni, Mattia, Sinéad Roden, Kirstin Scholten, Mark Stevenson, Federico Caniato, Dirk Pieter van Donk, and Andreas Wieland (2019). "The Future of Resilient Supply Chains." In: *Revisiting Supply Chain Risk*. Ed. by George A. Zsidisin and Michael Henke. Vol. 7. Springer Series in Supply Chain Management. Cham: Springer, pp. 169–186. DOI: 10.1007/978-3-030-03813-7_10

Dujak, Davor and Domagoj Sajter (2019). "Blockchain Applications in Supply Chain." In: *SMART Supply Network*. Ed. by Arkadiusz Kawa and Anna Maryniak. SpringerLink Bücher. Cham: Springer, pp. 21–46. DOI: 10.1007/978-3-319-91668-2_2

Eastwood, Gary (2017). *Why Blockchain is the Future of IoT*. URL: http://www.cio.com/article/3200029/internet-of-things/why-blockchain-is-the-future-of-iot.html

Fawcett, Stanley E., Amydee M. Fawcett, Sebastian Brockhaus, and Michael A. Knemeyer (Nov. 1, 2016). "The Collaboration Journey. Are We There yet?" In: *Supply Chain Management Review*

Fawcett, Stanley E. and Gregory M. Magnan (2002). "The rhetoric and reality of supply chain integration." In: *International Journal of Physical Distribution & Logistics Management* 32.5, pp. 339–361. DOI: 10.1108/09600030210436222

Ferrantino, Michael J. and Emine Elcin Koten (2017). "Understanding Supply Chain 4.0 and its potential impact on global value chains." In: *Global Value Chain Development Report 2019. Technological Innovation, Supply Chain Trade, and Workers in a Globalized World*. Ed. by World Trade Organization. Geneva, pp. 103–119. DOI: 10.30875/10529e69-en

Filippi, Primavera de and Benjamin Loveluck (2016). "The invisible politics of Bitcoin: governance crisis of a decentralised infrastructure." In: *Internet Policy Review* 5.3. DOI: 10.14763/2016.3.427

Fink, Arlene (2020). *Conducting research literature reviews. From the internet to paper*. 5th ed. Los Angeles et al.: SAGE

Fleiß, Jürgen (2010). "Paul Lazarsfelds typologische Methode und die Grounded Theory. Generierung und Qualität von Typologien." In: *Österreichische Zeitschrift für Soziologie* 35.3, pp. 3–18. DOI: 10.1007/s11614-010-0060-1

Flint, Daniel J., Robert B. Woodruff, and Sarah Fisher Gardial (2002). "Exploring the Phenomenon of Customers' Desired Value Change in a Business-to-Business Context." In: *Journal of Marketing* 66.4, pp. 102–117. DOI: 10.1509/jmkg.66.4.102.18517

Foroohar, Rana (2019). *Don't be evil. How big tech betrayed its founding principles - and all of us*. Allen Lane

Foth, M., M. Brereton, D. Vyas, A. Soro, B. Ploderer, J. Waycott, and A. Morrison (2017). "The promise of blockchain technology for interaction design." In: *OzCHI 2017 - Human Nature. Proceedings of the 29th Australian Computer-Human Interaction Conference (OzCHI 2017)*. Ed. by Alessandro Soro. ICPS. New York City, NY: The Association for Computing Machinery. DOI: 10.1145/3152771.3156168

Francisco, Kristoffer and David Swanson (2018). "The Supply Chain Has No Clothes: Technology Adoption of Blockchain for Supply Chain Transparency." In: *Logistics* 2.1, p. 2. DOI: 10.3390/logistics2010002

Galvez, J. F., J. C. Mejuto, and J. Simal-Gandara (2018). "Future challenges on the use of blockchain for food traceability analysis." In: *TrAC - Trends in Analytical Chemistry* 107, pp. 222–232. DOI: 10.1016/j.trac.2018.08.011

Gao, Zhimin, Lei Xu, Glenn Turner, Brijesh Patel, Nour Diallo, Lin Chen, and Weidong Shi (2018). "Blockchain-based Identity Management with Mobile Device." In: *CRYBLOCK '18. Proceedings of the 1st Workshop on Cryptocurrencies and Blockchains for Distributed Systems: June 15, 2018, Munich, Germany*. International Conference on Mobile Systems, Applications, and Services. New York City, NY: The Association for Computing Machinery, pp. 66–70. DOI: 10.1145/3211933.3211945

Gartner (2015). *Gartner Says 6.4 Billion Connected "Things" Will Be in Use in 2016, Up 30 Percent From 2015*. URL: http://www.gartner.com/newsroom/id/3165317

Gartner (Dec. 21, 2017). *Forecast: Internet of Things — Endpoints and Associated Services, Worldwide, 2017*. URL: https://www.gartner.com/en/documents/3840665/forecast-internet-of-things-endpoints-and-associated-ser

Gausdal, Anne H., Karen V. Czachorowski, and Marina Z. Solesvik (2018). "Applying Blockchain technology: Evidence from Norwegian companies." In: *Sustainability (Switzerland)* 10.6. DOI: 10.3390/su10061985

Gill, Sukhpal Singh et al. (2019). "Transformative effects of IoT, Blockchain and Artificial Intelligence on cloud computing: Evolution, vision, trends and open challenges." In: *Internet of Things* 8, p. 100118. DOI: 10.1016/j.iot.2019.100118

Goswami, Dhananjay, Angela M. Lagneaux, Mohan Swaminathan Venkataraman, Wendy Henry, Aashish Shrestha, and Stephen M. Dearing (Aug. 13, 2020). "Secure Voting Systems." US 2020/0258338 A1 (USA). United States Postal Service

Govindan, Kannan, Hamed Soleimani, and Devika Kannan (2015). "Reverse logistics and closed-loop supply chain: A comprehensive review to explore the future." In: *European Journal of Operational Research* 240.3, pp. 603–626. DOI: 10.1016/j.ejor.2014.07.012

Greif, Mark (2014). "Positionen." In: *Hipster. Eine transatlantische Diskussion*. Ed. by Mark Greif, Kathleen Ross, Dayna Tortorici, and Heinrich Geiselberger. Deutsche Erstausgabe, 3. Auflage, Sonderdruck. Edition Suhrkamp. Berlin: Suhrkamp, pp. 23–31

Groenfeldt, Tom (May 3, 2017). "IBM And Maersk Apply Blockchain To Container Shipping." In: *Forbes*

Guo, M., X. J. Liu, and W. Zhang (2018). "Using blockchain technology in human food chain provenance." In: *WIT Transactions on the Built Environment* 179. DOI: 10.2495/UG180361

Haber, Morey J. and Darran Rolls (2020). "Blockchain and Identity Management." In: *Identity Attack Vectors*. Ed. by Morey J. Haber and Darran Rolls. Berkeley, CA: Apress, pp. 175–187. DOI: 10.1007/978-1-4842-5165-2_20

Hackett, Robert (Oct. 19, 2016). "Walmart and IBM Are Partnering to Put Chinese Pork on a Blockchain." In: *Fortune*

Hackett, Robert (May 30, 2017). "Wal-Mart Explores Blockchain for Delivery Drones." In: *Fortune*

Hackius, Niels and Moritz Petersen (2017). "Blockchain in logistics and supply chain: trick or treat?" In: *Digitalization in supply chain management and logistics*. Ed. by Wolfgang Kersten, Thorsten Blecker, and Christian M. Ringle. Vol. 23. 23. epubli. DOI: 10.15480/882.1444

Hackius, Niels, Sven Reimers, and Wolfgang Kersten (2019). "The Privacy Barrier for Blockchain in Logistics: First Lessons from the Port of Hamburg." In: *Logistics Management*. Ed. by Christian Bierwirth, Thomas Kirschstein, and Dirk Sackmann. Lecture Notes in Logistics. Cham: Springer, pp. 45–61. DOI: 10.1007/978-3-030-29821-0_4

Hafeez, Kaamran (Feb. 23, 2015). "Remember when, on the Internet, nobody knew who you were?" In: *The New Yorker*

Hair, Joseph F., William C. Black, Barry J. Babin, and Rolph E. Anderson (2009). *Multivariate Data Analysis*. Upper Saddle River: Prentice Hall

Hald, Kim Sundtoft and Lorenzo Russo (2018). "Blockchain Technology and Supply Chain Performance." In: *The 30th NOFOMA Conference 2018*. Syddansk Universitet. Institut for Entreprenørskab og Relationsledelse

Hartley, Janet L. and William J. Sawaya (2019). "Tortoise, not the hare: Digital transformation of supply chain business processes." In: *Business Horizons* 62.6, pp. 707–715. DOI: 10.1016/j.bushor.2019.07.006

Hendricks, Kevin B., Brian W. Jacobs, and Vinod R. Singhal (2020). "Stock Market Reaction to Supply Chain Disruptions from the 2011 Great East Japan Earthquake." In: *Manufacturing & Service Operations Management* 22.4, pp. 683–699. DOI: 10.1287/msom.2019.0777

Hepp, Thomas, Patrick Wortner, Alexander Schönhals, and Bela Gipp (2018). "Securing Physical Assets on the Blockchain." In: *CRYBLOCK '18. Proceedings of the 1st Workshop on Cryptocurrencies and Blockchains for Distributed Systems: June 15, 2018, Munich, Germany*. International Conference on Mobile Systems, Applications, and Services. New York City, NY: The Association for Computing Machinery, pp. 60–65. DOI: 10.1145/3211933.3211944

Hermes Germany GmbH (2017). *Transparenz in der Supply Chain*. Hermes Germany GmbH. URL: https://www.hermes-supply-chain-blog.com/data-sharing-in-der-supply-chain-potential-noch-ungenutzt/

Hinckeldeyn, Johannes and Jochen Kreutzfeldt (2018a). "(Short Paper) Developing a Smart Storage Container for a Blockchain-Based Supply Chain Application." In: *2018 Crypto Valley Conference on Blockchain Technology (CVCBT)*, pp. 97–100. DOI: 10.1109/CVCBT.2018.00017

Hinckeldeyn, Johannes and Jochen Kreutzfeldt (2018b). "Blockchains in der Logistik. Anwendungsfälle einer neuen Technologie." In: *Hebezeuge, Fördermittel* 4, pp. 30–32

Hofman, Wout, Jacco Spek, and Christopher Brewster (2017). "Applying blockchain technology for hyperconnected logistics." In: *4th International Physical Internet*

Conference. July 4-6, 2017. Ed. by Christian Landschützer and Florian Ehrentraut. Logistik Werkstatt Graz. Graz

Hofmann, Erik and Marco Rüsch (2017). "Industry 4.0 and the current status as well as future prospects on logistics." In: *Computers in Industry* 89, pp. 23–34. DOI: 10.1016/j.compind.2017.04.002

Hoig, Stan (2015). *Land Run of 1889*. Ed. by Oklahoma Historical Society. URL: https://www.okhistory.org/publications/enc/entry.php?entry=LA014

Hua, Jing, Xiujuan Wang, Mengzhen Kang, Haoyu Wang, and Fei-Yue Wang (2018). "Blockchain Based Provenance for Agricultural Products: A Distributed Platform with Duplicated and Shared Bookkeeping." In: *2018 IEEE Intelligent Vehicles Symposium (IV)*, pp. 97–101. DOI: 10.1109/IVS.2018.8500647

Huertas, J., H. Liu, and S. Robinson (2018). "Eximchain: Supply Chain Finance solutions on a secured public, permissioned blockchain hybrid." In: *eximchain.com.s3.amazonaws.com*

Hulea, Mihai, Ovidiu Rosu, Radu Miron, and Adina Astilean (2018). "Pharmaceutical cold chain management: Platform based on a distributed ledger." In: *2018 IEEE International Conference on Automation, Quality and Testing, Robotics (AQTR). THETA 21st edition: 24th-26th May, Cluj-Napoca, Romania: proceedings*. Ed. by Liviu Miclea, Ioan Stoian, and Szilard Enyedi. [Piscataway, New Jersey]: IEEE, pp. 531–533. DOI: 10.1109/AQTR.2018.8402709

Huong Tran, Thi Thanh, Paul Childerhouse, and Eric Deakins (2016). "Supply chain information sharing: challenges and risk mitigation strategies." In: *Journal of Manufacturing Technology Management* 27.8, pp. 1102–1126. DOI: 10.1108/JMTM-03-2016-0033

Imeri, Adnan and Djamel Khadraoui (2018). "The Security and Traceability of Shared Information in the Process of Transportation of Dangerous Goods." In: *2018 9th IFIP International Conference on New Technologies, Mobility and Security (NTMS)*, pp. 1–5. DOI: 10.1109/NTMS.2018.8328751

Islam, Md Nazmul, Vinay C. Patii, and Sandip Kundu (2018). "On IC traceability via blockchain." In: *2018 International Symposium on VLSI Design, Automation and Test (VLSI-DAT). 16-19 April 2018*. VLSI-DAT and International Symposium on VLSI Design, Automation and Test. Piscataway, NJ: IEEE, pp. 1–4. DOI: 10.1109/VLSI-DAT.2018.8373269

Jabbar, Karim and Pernille Bjørn (2018). "Infrastructural Grind." In: *GROUP 2018. Proceedings of the 2018 ACM Conference on Supporting Groupwork: January 7-10, 2018, Sanibel Island, FL, USA*. Ed. by Andrea Forte, Michael Prilla, and Adriana Vivacqua. Vol. Part F139583. ACM Conference on Supporting Group Work et al.

New York City, NY: ACM Association for Computing Machinery, pp. 297–308. DOI: 10.1145/3148330.3148345

Kamilaris, Andreas, Agusti Fonts, and Francesc X. Prenafeta-Boldύ (2018). *The Rise of the Blockchain Technology in Agriculture and Food Supply Chain*. Barcelona: Institute of Agriculture and Food Research and Technology

Kastelein, Richard (Feb. 25, 2020). *KLM To Use Blockchain to Streamline Financial Processes Thanks to Amsterdam-based Unchain and R3*. URL: https://medium.com/@expathos/klm-to-use-blockchain-to-streamline-financial-processes-thanks-to-amsterdam-based-unchain-and-r3-f913a1d43d97

Kersten, Wolfgang, Florian Dörries, Sebastian Lodemann, Marius Indorf, and Merlin Müller (2019). "Qualifizierung von Führungskräften für die digitale Ökonomie. Ein Erfolgsfaktor erfolgreicher Geschäftsmodellinnovationen." In: *Digitale Transformation – Gutes Arbeiten und Qualifizierung aktiv gestalten*. Ed. by Dieter Spath and Birgit Spanner-Ulmer. GITO, pp. 163–186

Kersten, Wolfgang, Mischa Seier, Birgit von See, Niels Hackius, and Timo Maurer (2017). *Trends and Strategies in Logistics and Supply Chain Management – Digital Transformation Opportunities*. Hamburg: DVV Media Group

Kersten, Wolfgang, Birgit von See, and Marius Indorf (2018). "Digitalisierung als Wegbereiter für effizientere Wertschöpfungsnetzwerke." In: *Marktorientiertes Produkt- und Produktionsmanagement in digitalen Umwelten*. Ed. by Anshuman Khare, Dagmar Kessler, and Jan Wirsam. Wiesbaden: Springer, pp. 101–117. DOI: 10.1007/978-3-658-21637-5_8

Kim, Henry M. and Marek Laskowski (2018a). "Toward an ontology-driven blockchain design for supply-chain provenance." In: *Intelligent Systems in Accounting, Finance and Management* 25.1, pp. 18–27. DOI: 10.1002/isaf.1424

Kim, S. and D. Kim (2018b). "Design of an innovative blood cold chain management system using blockchain technologies." In: *ICIC Express Letters, Part B: Applications* 9.10, pp. 1067–1073. DOI: 10.24507/icicelb.09.10.1067

Kluge, Susann (2000). "Empirically Grounded Construction of Types and Typologies in Qualitative Social Research." In: *Forum: Qualitative Social Research* 1.1

Ko, Taehyun, Jaeram Lee, and Doojin Ryu (2018). "Blockchain Technology and Manufacturing Industry: Real-Time Transparency and Cost Savings." In: *Sustainability (Switzerland)* 10.11, p. 4274. DOI: 10.3390/su10114274

Korpela, Kari, Jukka Hallikas, and Tomi Dahlberg (2017). "Digital Supply Chain Transformation toward Blockchain Integration." In: *Hawaii International Conference on System Sciences 2017 (HICSS-50). Hilton Waikoloa Village, Hawaii, January 4-7, 2017*. Hawaii International Conference on System Sciences and Hawaii International Conference on System Sciences. DOI: 10.24251/HICSS.2017.506

Kosba, Ahmed, Andrew Miller, Elaine Shi, Zikai Wen, and Charalampos Papamanthou (2016). "Hawk: The Blockchain Model of Cryptography and Privacy-Preserving Smart Contracts." In: *2016 IEEE Symposium on Security and Privacy (SP)*. 2016 IEEE Symposium on Security and Privacy (SP) (San Jose, CA, May 22, 2016). IEEE, pp. 839–858. DOI: 10.1109/SP.2016.55

Kouhizadeh, Mahtab, Sara Saberi, and Joseph Sarkis (2021). "Blockchain technology and the sustainable supply chain: Theoretically exploring adoption barriers." In: *International Journal of Production Economics* 231, p. 107831. DOI: 10.1016/j.ijpe.2020.107831

Kouhizadeh, Mahtab and Joseph Sarkis (2018). "Blockchain Practices, Potentials, and Perspectives in Greening Supply Chains." In: *Sustainability (Switzerland)* 10.10, p. 3652. DOI: 10.3390/su10103652

Kshetri, Nir (2017). "Blockchain's roles in strengthening cybersecurity and protecting privacy." In: *Telecommunications Policy* 41.10, pp. 1027–1038. DOI: 10.1016/j.telpol.2017.09.003

Kuhi, Kristjan, Kati Kaare, and Ott Koppel (2018). "Ensuring performance measurement integrity in logistics using blockchain." In: *Proceedings of the 2018 IEEE International Conference on Service Operations and Logistics, and Informatics (SOLI 2018). 31 July-2 August 2018, Singapore*. IEEE International Conference on Service Operations and Logistics, and Informatics, Institute of Electrical and Electronics Engineers, and SOLI. Piscataway, NJ: IEEE, pp. 256–261. DOI: 10.1109/SOLI.2018.8476737

Lacity, Mary C. (2018). "Addressing key challenges to making enterprise blockchain applications a reality." In: *MIS Quarterly Executive* 17.3, pp. 201–222

Lambert, Douglas M. (2014). "Supply Chain Management." In: *Supply chain management. Processes, partnerships, performance*. Ed. by Douglas M. Lambert. 4th ed., pp. 1–22

Lanko, A., N. Vatin, and A. Kaklauskas (2018). "Application of RFID combined with blockchain technology in logistics of construction materials." In: *MATEC Web of Conferences. International Science Conference SPbWOSCE-2017 "Business Technologies for Sustainable Urban Development"*. Ed. by Igor Ilin and Olga Kalinina. Vol. 170. 170. St. Petersburg, p. 03032. DOI: 10.1051/matecconf/201817003032

Lantz, Lorne (2016). *New Kids on the Blockchain*. With annots. by TEDxHamburgSalon. URL: https://youtu.be/A1Vbrxkqjwc

Larson, Paul D., Richard F. Poist, and Árni Halldórsson (2007). "Perspectives on Logistics vs. Scm: A Survey of Scm Professionals." In: *Journal of Business Logistics* 28.1, pp. 1–24. DOI: 10.1002/j.2158-1592.2007.tb00230.x

Lee, Hau L, V. Padmanabhan, and Seungjin Whang (1997). "The Bullwhip Effect in Supply Chains." In: *Sloan Management Review*, pp. 93–102

Lee, Jong-Hyouk and Marc Pilkington (2017). "How the Blockchain Revolution Will Reshape the Consumer Electronics Industry [Future Directions]." In: *IEEE Consumer Electronics Magazine* 6.3, pp. 19–23. DOI: 10.1109/MCE.2017.2684916

Li, Jing and Xinyan Wang (2018). "Research on the Application of Blockchain in the Traceability System of Agricultural Products." In: *2018 2nd IEEE Advanced Information Management, Communicates, Electronic and Automation Control Conference (IMCEC)*, pp. 2637–2640. DOI: 10.1109/IMCEC.2018.8469456

Liao, Da-Yin and Xuehong Wang (2018). "Applications of Blockchain Technology to Logistics Management in Integrated Casinos and Entertainment." In: *Informatics*. Vol. 5. Multidisciplinary Digital Publishing Institute, p. 44. DOI: 10.3390/informatics5040044

Liu, Yang, Debiao He, Mohammad S. Obaidat, Neeraj Kumar, Muhammad Khurram Khan, and Kim-Kwang Raymond Choo (2020). "Blockchain-based identity management systems: A review." In: *Journal of Network and Computer Applications*, p. 102731. DOI: 10.1016/j.jnca.2020.102731

Loklindt, Christopher, Marc-Philip Moeller, and Aseem Kinra (2018). "How Blockchain Could Be Implemented for Exchanging Documentation in the Shipping Industry." In: *Dynamics in Logistics*. Ed. by Michael Freitag, Herbert Kotzab, and Jürgen Pannek. Lecture Notes in Logistics. Universität Bremen. Cham: Springer, pp. 194–198. DOI: 10.1007/978-3-319-74225-0_27

Lomas, Natasha (June 29, 2015). "Everledger Is Using Blockchain To Combat Fraud, Starting With Diamonds." In: *TechCrunch*

Low, Kelvin F. K. and Eliza Mik (2020). "Pause the Blockchain Legal Revolution." In: *International and Comparative Law Quarterly* 69.1, pp. 135–175. DOI: 10.1017/S0020589319000502

Lu, Qinghua and Xiwei Xu (2017). "Adaptable Blockchain-Based Systems: A Case Study for Product Traceability." In: *IEEE Software* 34.6, pp. 21–27. DOI: 10.1109/MS.2017.4121227

Lu, Yingjin, Zhangyi Xu, and Xisheng Le (2019). "Research on the Application of Block Chain Technology in Military Supply Chain." In: *Advances in Intelligent Systems and Computing* 842, pp. 915–920. DOI: 10.1007/978-3-319-98776-7_109

Lufkin, Brian (2017). *The reasons you can't be anonymous anymore*. BBC Future. URL: https://www.bbc.com/future/article/20170529-the-reasons-you-can-never-be-anonymous-again

Lumineau, Fabrice, Wenqian Wang, and Oliver Schilke (2021). "Blockchain Governance — A New Way of Organizing Collaborations?" In: *Organization Science* 32, pp. 500–521. DOI: 10.1287/orsc.2020.1379

Luo, Yadong (2007). "A coopetition perspective of global competition." In: *Journal of World Business* 42.2, pp. 129–144. DOI: 10.1016/j.jwb.2006.08.007

Lyall, Allan, Pierre Mercier, and Stefan Gstettner (June 15, 2018). "The Death of Supply Chain Management." In: *Harvard Business Review*

Mackey, Tim K. and Gaurvika Nayyar (2017). "A Review of Existing and Emerging Digital Technologies to Combat the Global Trade in Fake Medicines." In: *Expert Opinion on Drug Safety* 16.5, pp. 587–602. DOI: 10.1080/14740338.2017.1313227

Madenas, Nikolaos, Ashutosh Tiwari, Christopher J. Turner, and James Woodward (2014). "Information flow in supply chain management: A review across the product lifecycle." In: *CIRP Journal of Manufacturing Science and Technology* 7.4, pp. 335–346. DOI: 10.1016/j.cirpj.2014.07.002

Madhwal, Yash and Peter Panfilov (2017). "Blockchain And Supply Chain Management: Aircrafts' Parts' Business Case." In: *28th DAAAM International Symposium*. Ed. by Branko Katalinic. Vol. 1. Wien, pp. 1051–1056. DOI: 10.2507/28th.daaam.proceedings.146

Madichie, Nnamdi O. and Fred A. Yamoah (2017). "Revisiting the European Horsemeat Scandal: The Role of Power Asymmetry in the Food Supply Chain Crisis." In: *Thunderbird International Business Review* 59.6, pp. 663–675. DOI: 10.1002/tie.21841

Maes, Jochen and Thierry Vanelslander (2012). "The Use of Bicycle Messengers in the Logistics Chain, Concepts Further Revised." In: *Procedia - Social and Behavioral Sciences* 39, pp. 409–423. DOI: 10.1016/j.sbspro.2012.03.118

Manevich, Yacov, Artem Barger, and Yoav Tock (2018). "Service Discovery for Hyperledger Fabric." In: *DEBS'18. Proceedings of the 12th ACM International Conference on Distributed and Event-Based Systems*. New York City, NY: The Association for Computing Machinery, pp. 226–229. DOI: 10.1145/3210284.3219766

Marx, Matthias, Erik Sy, Christian Burkert, and Hannes Federrath (2018). "Anonymity Online – Current Solutions and Challenges." In: *Privacy and Identity Management. The Smart Revolution*. Vol. 526. IFIP advances in information and communication technology. Cham: Springer, pp. 38–55. DOI: 10.1007/978-3-319-92925-5_4

Meade, Adam W. and Bartholomew S. Craig (2012). "Identifying Careless Responses in Survey Data." In: *Psychological Methods* 17.3, pp. 437–455. DOI: 10.1037/a0028085

Meng, Mark H. and Yaou Qian (2018). "A Blockchain Aided Metric for Predictive Delivery Performance in Supply Chain Management." In: *Proceedings of the 2018 IEEE International Conference on Service Operations and Logistics, and Informatics (SOLI 2018)*. IEEE International Conference on Service Operations and Logistics, and Informatics, Institute of Electrical and Electronics Engineers, and SOLI. Piscataway, NJ: IEEE, pp. 285–290. DOI: 10.1109/SOLI.2018.8476723

Min, Hokey (2018). "Blockchain technology for enhancing supply chain resilience." In: *Business Horizons*. DOI: 10.1016/j.bushor.2018.08.012

Min, Soonhong, Zach G. Zacharia, and Carlo D. Smith (2019). "Defining Supply Chain Management: In the Past, Present, and Future." In: *Journal of Business Logistics* 40.1, pp. 44–55. DOI: 10.1111/jbl.12201

Mittal, Sachin, Tsz Wang Tam Cfa, and Chris Ko Cfa (2018). "Internet of Things. The Pillar of Artificial Intelligence." In: *DBS Asian Insights sector briefing* 63

Monczka, Robert M., Robert B. Handfield, Larry C. Giunipero, and James L. Patterson (2016). *Purchasing and supply chain management*. 6th ed. Andover: Cengage Learning Inc

Morabito, Vincenzo (2017). *Business Innovation Through Blockchain*. Cham: Springer. DOI: 10.1007/978-3-319-48478-5

Morkunas, Vida J., Jeannette Paschen, and Edward Boon (2019). "How blockchain technologies impact your business model." In: *Business Horizons* 62.3, pp. 295–306. DOI: 10.1016/j.bushor.2019.01.009

Möser, Malte et al. (2018). "An Empirical Analysis of Traceability in the Monero Blockchain." In: *Proceedings on Privacy Enhancing Technologies* 2018.3, pp. 143–163. DOI: 10.1515/popets-2018-0025

Mühle, Alexander, Andreas Grüner, Tatiana Gayvoronskaya, and Christoph Meinel (2018). "A survey on essential components of a self-sovereign identity." In: *Computer Science Review* 30, pp. 80–86. DOI: 10.1016/j.cosrev.2018.10.002

Munn, Zachary, Micah D. J. Peters, Cindy Stern, Catalin Tufanaru, Alexa McArthur, and Edoardo Aromataris (2018). "Systematic review or scoping review? Guidance for authors when choosing between a systematic or scoping review approach." In: *BMC medical research methodology* 18.1, p. 143. DOI: 10.1186/s12874-018-0611-x

Musiani, Francesca, Alexandre Mallard, and Cécile Méadel (2017). "Governing what wasn't meant to be governed." In: *Bitcoin and Beyond*. Ed. by Malcolm Campbell-Verduyn. Routledge, pp. 133–156. DOI: 10.4324/9781315211909-7

Nærland, K., R. Beck, C. Müller-Bloch, and S. Palmund (2018). "Blockchain to Rule the Waves - Nascent Design Principles for Reducing Risk and Uncertainty in Decentralized Environments." In: *Transforming society with digital innovation. 38th International Conference on Information Systems (ICIS 2017)*. International

Conference on Information Systems, Association for Information Systems, and ICIS. Red Hook, NY: Curran Associates Inc

Naidu, Vishal, Kumaresan Mudliar, Abhishek Naik, and Prof Prasenjit Bhavathankar (2018). "A Fully Observable Supply Chain Management System Using Block Chain and IOT." In: *2018 3rd International Conference for Convergence in Technology, I2CT 2018*, pp. 1–4. DOI: 10.1109/I2CT.2018.8529725

Nakamoto, Satoshi (2008). *Bitcoin: A Peer-to-Peer Electronic Cash System*. URL: https://bitcoin.org/bitcoin.pdf

Nandi, Madhavi Latha, Santosh Nandi, Hiram Moya, and Hale Kaynak (2020). "Blockchain technology-enabled supply chain systems and supply chain performance: a resource-based view." In: *Supply Chain Management: An International Journal* ahead-of-print.ahead-of-print. DOI: 10.1108/SCM-12-2019-0444

Nedbal, Dietmar (2013). "A process model to guide the integration of business processes and services within and across organisations." In: *International Journal of Services, Economics and Management* 5.1/2, p. 154. DOI: 10.1504/IJSEM.2013.051855

Ngamsuriyaroj, Sudsanguan, Thammarith Likittheerameth, Amorntape Kahutson, and Thunyaporn Pathummasut (2018). "Package Delivery System Based on Blockchain Infrastructure." In: *2018 Seventh ICT International Student Project Conference (ICT-ISPC)*, pp. 1–6. DOI: 10.1109/ICT-ISPC.2018.8523944

Norrman, Andreas and Ulf Jansson (2004). "Ericsson's proactive supply chain risk management approach after a serious sub-supplier accident." In: *International Journal of Physical Distribution & Logistics Management* 34.5, pp. 434–456. DOI: 10.1108/09600030410545463

Novotny, Petr, Qi Zhang, Richard Hull, Salman Baset, Jim Laredo, Roman Vaculin, Daniel L. Ford, and Donna N. Dillenberger (2018). "Permissioned blockchain technologies for academic publishing." In: *Information Services and Use* 38.3, pp. 159–171. DOI: 10.3233/ISU-180020

O'Marah, Kevin (2017). *Blockchain For Supply Chain: Enormous Potential Down The Road*. URL: https://www.forbes.com/sites/kevinomarah/2017/03/09/blockchain-for-supply-chain-enormous-potential-down-the-road/

Orf, Darren (Apr. 15, 2014). "Transporting an Entire T. Rex." In: *Popular Mechanics*

Palm, Emanuel, Olov Schelen, and Ulf Bodin (2018). "Selective Blockchain Transaction Pruning and State Derivability." In: *2018 Crypto Valley Conference on Blockchain Technology (CVCBT)*, pp. 31–40. DOI: 10.1109/CVCBT.2018.00009

Park, Kyunghee (Apr. 18, 2018). "Blockchain Is About to Revolutionize the Shipping Industry." In: *Bloomberg*

Patole, Deepti, Yogita Borse, Jayesh Jain, and Shreya Maher (2020). "Personal Identity on Blockchain." In: *Advances in Computing and Intelligent Systems*. Ed. by Harish Sharma, Kannan Govindan, Ramesh C. Poonia, Sandeep Kumar, and Wael M. El-Medany. Algorithms for Intelligent Systems. Singapore: Springer, pp. 439–446. DOI: 10.1007/978-981-15-0222-4_41

Pedersen, Asger B., Marten Risius, and Roman Beck (2019). "A Ten-Step Decision Path to Determine When to Use Blockchain Technologies." In: *MIS Quarterly Executive*, pp. 99–115. DOI: 10.17705/2msqe.00010

Perks, Helen, Christian Kowalkowski, Lars Witell, and Anders Gustafsson (2017). "Network orchestration for value platform development." In: *Industrial Marketing Management* 67, pp. 106–121. DOI: 10.1016/j.indmarman.2017.08.002

Petersen, Moritz (2017). "Considering sustainability in the development of consumer goods." TUHH Universitätsbibliothek

Petersen, Moritz, Niels Hackius, and Birgit von See (2018). "Mapping the sea of opportunities: Blockchain in supply chain and logistics." In: *it - Information Technology* 0.0, p. 118. DOI: 10.1515/itit-2017-0031

Petersen, Moritz, Wolfgang Kersten, and Sebastian Brockhaus (2016). "Berücksichtigung der Nachhaltigkeit in der Entwicklung und Vermarktung von Konsumgütern." In: *Forschung für Nachhaltigkeit an deutschen Hochschulen*. Ed. by Walter Leal Filho. Wiesbaden: Springer, pp. 331–347. DOI: 10.1007/978-3-658-10546-4_19

Petroni, Benedito Cristiano A., Elisângela Mônaco de Moraes, and Rodrigo Franco Gonçalves (2018). "Big Data Analytics for Logistics and Distributions Using Blockchain." In: *Smart manufacturing for industry 4.0*. Ed. by Ilkyeong Moon, Gyu M. Lee, Jinwoo Park, Dimitris Kiritsis, and Gregor von Cieminski. Vol. 536. IFIP advances in information and communication technology 536. APMS et al. Cham: Springer, pp. 363–369. DOI: 10.1007/978-3-319-99707-0_45

Pfohl, Hans-Christian (2018). *Logistiksysteme*. Berlin, Heidelberg: Springer. DOI: 10.1007/978-3-662-56228-4

Pilkington, Marc (2016). "Blockchain Technology: Principles and Applications." In: *Research Handbook on Digital Transformations*. Ed. by F. Xavier Olleros and Majlinda Zhegu. Edward Elgar Publishing, pp. 1–39

Popejoy, Stuart (July 2, 2019). "Why IBM's Blockchain Isn't a Real Blockchain." In: *Cointelegraph*

Popper, Nathaniel and Steve Lohr (Mar. 4, 2017). "Blockchain: A Better Way to Track Pork Chops, Bonds, Bad Peanut Butter?" In: *The New York Times*

Promberger, Markus (2011). *Typenbildung mit quantitativen und qualitativen Daten*. Ed. by Institut für Arbeitsmarkt- und Berufsforschung der Bundesagentur für Arbeit

Queiroz, Maciel M. and Samuel Fosso Wamba (2019a). "Blockchain adoption challenges in supply chain: An empirical investigation of the main drivers in India and the USA." In: *International Journal of Information Management* 46, pp. 70–82. DOI: 10.1016/j.ijinfomgt.2018.11.021

Queiroz, Maciel M., Renato Telles, and Silvia H. Bonilla (2019b). "Blockchain and supply chain management integration: a systematic review of the literature." In: *Supply Chain Management: An International Journal* 25.2, pp. 241–254. DOI: 10.1108/SCM-03-2018-0143

Quesnelle, Jeffrey (Dec. 4, 2017). *On the linkability of Zcash transactions*. URL: http://arxiv.org/pdf/1712.01210v1

Rancic Moogk, Dobrila (2012). "Minimum Viable Product and the Importance of Experimentation in Technology Startups." In: *Technology Innovation Management Review* 2.3, pp. 23–26. DOI: 10.22215/timreview535

Rao, A. Ravishankar and Daniel Clarke (2020). "Perspectives on emerging directions in using IoT devices in blockchain applications." In: *Internet of Things* 10, p. 100079. DOI: 10.1016/j.iot.2019.100079

Reimers, Sven and Wolfgang Kersten (2020). "Schöne neue Transparenz mit Blockchain?" In: *Industrie 4.0 Management* 2020.2, pp. 11–14. DOI: 10.30844/I40M_20-1_S11-14

Rejeb, Abderahman (2018a). "Blockchain Potential in Tilapia Supply Chain in Ghana." In: *Acta Technica Jaurinensis* 11.2, pp. 104–118. DOI: 10.14513/actatechjaur.v11.n2.462

Rejeb, Abderahman (2018b). "Halal Meat Supply Chain Traceability based on HACCP, Blockchain and Internet of Things." In: *Acta Technica Jaurinensis* 11.4, pp. 218–247. DOI: 10.14513/actatechjaur.v11.n4.467

Ries, Eric (2011). *The lean startup. How today's entrepreneurs use continuous innovation to create radically successful businesses*. 1st ed. New York City, NY: Crown Business

Robert Koch-Institute (Sept. 1, 2011). *Final presentationand evaluation of the epidemiological findings in the EHEC O104:H4 outbreak, Germany 2011*. Robert Koch-Institute

Roeck, Dominik, Henrik Sternberg, and Erik Hofmann (2020). "Distributed ledger technology in supply chains: a transaction cost perspective." In: *International Journal of Production Research* 58.7, pp. 2124–2141. DOI: 10.1080/00207543.2019.1657247

Roiss, Stephan (2020). *Triceratops*. Wien: Kremayr & Scheriau

Rubio, María Alejandra, Giovanny Mauricio Tarazona, and Leonardo Contreras (2018). "Big Data and Blockchain Basis for Operating a New Archetype of Supply Chain." In: *Data mining and big data*. Ed. by Ying Tan, Yuhui Shi, and Qirong Tang. Vol. 10943. Lecture Notes in Computer Science 10387. International Conference on Data Mining and Big Data. Cham: Springer, pp. 659–669. DOI: 10.1007/978-3-319-93803-5_62

Saberi, Sara, Mahtab Kouhizadeh, Joseph Sarkis, and Lejia Shen (2018). "Blockchain technology and its relationships to sustainable supply chain management." In: *International Journal of Production Research* 57.7, pp. 2117–2135. DOI: 10.1080/00207543.2018.1533261

Sander, Fabian, Janjaap Semeijn, and Dominik Mahr (2018). "The acceptance of blockchain technology in meat traceability and transparency." In: *British Food Journal* 120.9, pp. 2066–2079. DOI: 10.1108/BFJ-07-2017-0365

Santonino III, Michael D., Constantine M. Koursaris, and Michael J. Williams (2018). "Modernizing the Supply Chain of Airbus by Integrating RFID and Blockchain Processes." In: *International Journal of Aviation, Aeronautics, and Aerospace* 5.4. DOI: 10.15394/ijaaa.2018.1265

Schmidt, Christoph G. and Stephan M. Wagner (2019). "Blockchain and supply chain relations: A transaction cost theory perspective." In: *Journal of Purchasing and Supply Management* 25.4, p. 100552. DOI: 10.1016/j.pursup.2019.100552

Schrepel, Thibault (2020). "Libra: A Concentrate of 'Blockchain Antitrust'." In: *Michigan Law Online* 160.118

Schwemmer, Martin (2019). *TOP 100 in European Transport and Logistics Services 2019/2020*. In collab. with Alexander Pflaum. Hamburg: DVV Media Group

Scully, Padraig and Michael Hobig (2019). "Exploring the impact of blockchain on digitized Supply Chain flows: A literature review." In: *2019 Sixth International Conference on Software Defined Systems (SDS)*. 2019 Sixth International Conference on Software Defined Systems (SDS) (Rome, Italy). International Conference on Software Defined Systems and SDS. Piscataway, NJ: IEEE, pp. 278–283. DOI: 10.1109/SDS.2019.8768573

Sermpinis, Thomas and Christos Sermpinis (Oct. 22, 2018). *Traceability Decentralization in Supply Chain Management Using Blockchain Technologies*. URL: https://www.uport.me

Shaffer, Erica (2017). *Walmart, IBM Provide Blockchain Update*. URL: https://www.meatpoultry.com/articles/16484-walmart-ibm-provide-blockchain-update

Sharma, P. K., N. Kumar, and J. H. Park (2018). "Blockchain-based Distributed Framework for Automotive Industry in a Smart City." In: *IEEE Transactions on Industrial Informatics*. DOI: 10.1109/TII.2018.2887101

Shein, Esther (Sept. 11, 2020). "Walmart Canada IoT-blockchain system nearly eliminates shipping discrepancies." In: *TechRepublic*

Shekarian, Ehsan (2020). "A review of factors affecting closed-loop supply chain models." In: *Journal of Cleaner Production* 253, p. 119823. DOI: 10.1016/j.jclepro.2019.119823

Singh, Rajani, Ashutosh Dhar Dwivedi, and Gautam Srivastava (2020). "Internet of Things Based Blockchain for Temperature Monitoring and Counterfeit Pharmaceutical Prevention." In: *Sensors (Switzerland)* 20.14. DOI: 10.3390/s20143951

Snowden, Edward J. (2019). *Permanent record*

Stahlbock, Robert, Leonard Heilig, and Stefan Voß (2018). "Blockchain in der maritimen Logistik." In: *HMD Praxis der Wirtschaftsinformatik* 55.6, pp. 1185–1203. DOI: 10.1365/s40702-018-00464-8

Steiner, Peter (July 5, 1993). "On the Internet, Nobody Knows You're a Dog." In: *The New Yorker* 69.20

Strübing, Jörg (2008). *Grounded Theory. Zur sozialtheoretischen und epistemologischen Fundierung des Verfahrens der empirisch begründeten Theoriebildung*. 2nd ed. Vol. 15. Qualitative Sozialforschung. Wiesbaden: VS Verlag für Sozialwissenschaften. DOI: 10.1007/978-3-531-91968-3

Suddaby, Roy (2006). "From the Editors: What Grounded Theory is Not." In: *Academy of Management Journal* 49.4, pp. 633–642. DOI: 10.5465/AMJ.2006.22083020

Sudhan, Amool and Manisha J. Nene (2017). "Employability of blockchain technology in defence applications." In: *Proceedings of the International Conference on Intelligent Sustainable Systems (ICISS 2017)*. International Conference on Intelligent Sustainable Systems, Institute of Electrical and Electronics Engineers, and ICISS. Piscataway, NJ: IEEE, pp. 630–637. DOI: 10.1109/ISS1.2017.8389247

Sund, Tobias, Claes Lööf, Simin Nadjm-Tehrani, and Mikael Asplund (2020). "Blockchain-based event processing in supply chains – A case study at IKEA." In: *Robotics and Computer-Integrated Manufacturing* 65, p. 101971. DOI: 10.1016/j.rcim.2020.101971

Supranee, Sowichaya. and Siriluck Rotchanakitumnuai (2017). "The Acceptance of the Application of Blockchain Technology in the Supply Chain Process of the Thai Automotive Industry." In: *Proceedings of The Seventeenth International Conference on Electronic Business*. Ed. by Eldon Y. Li and Kathy Ning Shen. Dubai, pp. 252–257

Sutherland, William J. et al. (2017). "A 2017 Horizon Scan of Emerging Issues for Global Conservation and Biological Diversity." In: *Trends in Ecology and Evolution* 32.1, pp. 31–40. DOI: 10.1016/j.tree.2015.11.007

Swan, Melanie (2015). *Blockchain. Blueprint for a new economy*. 1st ed. Safari Tech Books Online. Beijing: O'Reilly

Swan, Melanie (2018). "Blockchain for Business: Next-Generation Enterprise Artificial Intelligence Systems." In: *Blockchain technology. Platforms, tools and use cases*. Ed. by Pethuru Raj and Ganesh Chandra Deka. Vol. 111. Advances in Computers volume 111. Cambridge, MA: Academic Press, pp. 121–162. DOI: 10.1016/bs.adcom.2018.03.013

Sylim, Patrick, Fang Liu, Alvin Marcelo, and Paul Fontelo (2018). "Blockchain Technology for Detecting Falsified and Substandard Drugs in Distribution: Pharmaceutical Supply Chain Intervention." In: *JMIR Research Protocols* 7.9. DOI: 10.2196/10163

Takhar, Sukhraj S. and Kapila Liyanage (2018). "Blockchain application in supply chain chemical substance reporting." In: *22nd Cambridge International Manufacturing Symposium*. Ed. by Jagjit Singh Srai. Institute for Manufacturing, University of Cambridg. Cambridge

Tan, Bowen, Jiaqi Yan, Si Chen, and Xingchen Liu (2018). "The Impact of Blockchain on Food Supply Chain: The Case of Walmart." In: *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)* 11373, pp. 167–177. DOI: 10.1007/978-3-030-05764-0_18

Tapscott, Don and Alex Tapscott (2016). *Blockchain Revolution*. 1st ed. New York City, NY: Penguin Random House

The Economist (Oct. 31, 2015). "The great chain of being sure about things." In: *The Economist*

Thesmar, Hilary S. and Shawn K. Stevens (2019). "Meat and Poultry Traceability – Its History and Continuing Challenges." In: *Food Traceability*. Ed. by Jennifer McEntire and Andrew W. Kennedy. Vol. 50. Cham: Springer, pp. 71–80. DOI: 10.1007/978-3-030-10902-8_6

Thiruchelvam, V., A. S. Mughisha, M. Shahpasand, and M. Bamiah (2018). "Blockchain-based technology in the coffee supply chain trade: Case of Burundi coffee." In: *Journal of Telecommunication, Electronic and Computer Engineering* 10.3-2, pp. 121–125

Tian, Feng (2016). "An agri-food supply chain traceability system for China based on RFID & blockchain technology." In: *2016 13th International Conference on Service Systems and Service Management (ICSSSM)*. Ed. by B. J. Yang, J. Chen, X. Q. Cai, K. D. Qin, and C. Zhou. International Conference on Service Systems

and Service Management. Tsinghua Univ Inst Elect & Elect Engineers IEEE Syst Chinese Univ. Hong Kong S China Univ Technol. New York City, NY: IEEE. DOI: 10.1109/ICSSSM.2016.7538424

Tian, Feng (2017). "A supply chain traceability system for food safety based on HACCP, blockchain & Internet of things." In: *2017 14th International Conference on Service Systems and Service Management (ICSSSM)*. Ed. by J. Tang, J. Chen, and X. Q. Cai. International Conference on Service Systems and Service Management. Tsinghua Univ Chinese Univ Hong Kong IEEE Syst Man & Cybernet Soc. New York City, NY: IEEE. DOI: 10.1109/ICSSSM.2017.7996119

Tönnissen, Stefan and Frank Teuteberg (2018). "Using Blockchain Technology for Business Processes in Purchasing – Concept and Case Study-Based Evidence." In: *Business Information Systems. Proceedings*. Ed. by Witold Abramowicz and Adrian Paschke. Vol. 320. Lecture Notes in Business Information Processing 320. BIS and Business Information Systems. Cham: Springer, pp. 253–264. DOI: 10.1007/978-3-319-93931-5_18

Tönnissen, Stefan and Frank Teuteberg (2020). "Analysing the impact of blockchain-technology for operations and supply chain management: An explanatory model drawn from multiple case studies." In: *International Journal of Information Management* 52, p. 101953. DOI: 10.1016/j.ijinfomgt.2019.05.009

Treiblmaier, Horst (2018). "The impact of the blockchain on the supply chain: a theory-based research framework and a call for action." In: *Supply Chain Management: An International Journal*, SCM–01–2018–0029. DOI: 10.1108/SCM-01-2018-0029

Trienekens, J. H., P. M. Wognum, A.J.M. Beulens, and J.G.A.J. van der Vorst (2012). "Transparency in complex dynamic food supply chains." In: *Advanced Engineering Informatics* 26.1, pp. 55–65. DOI: 10.1016/j.aei.2011.07.007

Tse, Daniel, Bowen Zhang, Yuchen Yang, Chenli Cheng, and Haoran Mu (2017). "Blockchain application in food supply information security." In: *2017 IEEE International Conference on Industrial Engineering and Engineering Management (IEEM)*. IEEE, pp. 1357–1361. DOI: 10.1109/IEEM.2017.8290114

Underwood, Sarah (2016). "Blockchain Beyond Bitcoin." In: *Communications of the ACM* 59.11, pp. 15–17. DOI: 10.1145/2994581

Valenta, Martin and Philipp Sandner (June 25, 2017). *Comparison of Ethereum, Hyperledger Fabric and Corda*. Ed. by Frankfurt School Blockchain Center

van Engelenburg, Sélinde, Marijn F.W.H.A. Janssen, and Bram Klievink (2018). "A Blockchain Architecture for Reducing the Bullwhip Effect." In: *Business Modeling and Software Design*. Ed. by Boris Shishkov. Vol. 319. 319. Cham: Springer, pp. 69–82. DOI: 10.1007/978-3-319-94214-8_5

van Engelenburg, Sélinde, Marijn F.W.H.A. Janssen, and Bram Klievink (2019). "Design of a software architecture supporting business-to-government information sharing to improve public safety and security." In: *Journal of Intelligent Information Systems* 52.3, pp. 595–618. DOI: 10.1007/s10844-017-0478-z

Varghese, Blesson, Massimo Villari, Omer Rana, Philip James, Tejal Shah, Maria Fazio, and Rajiv Ranjan (2018). "Realizing Edge Marketplaces: Challenges and Opportunities." In: *IEEE Cloud Computing* 5.6, pp. 9–20. DOI: 10.1109/MCC.2018.064181115

Verhoeven, Peter, Florian Sinn, and Tino Herden (2018). "Examples from Blockchain Implementations in Logistics and Supply Chain Management: Exploring the Mindful Use of a New Technology." In: *Logistics* 2.3, pp. 1–20. DOI: 10.3390/logistics2030020

von See, Birgit (2019). "Ein Handlungsrahmen für die digitale Transformation in Wertschöpfungsnetzwerken." TUHH Universitätsbibliothek

Walmart Inc. (Sept. 24, 2018). *In Wake of Romaine E. coli Scare, Walmart Deploys Blockchain to Track Leafy Greens*. URL: https://corporate.walmart.com/newsroom/2018/09/24/in-wake-of-romaine-e-coli-scare-walmart-deploys-blockchain-to-track-leafy-greens

Wang, Jun, Peng Wu, Xiangyu Wang, and Wenchi Shou (2017). "The outlook of blockchain technology for construction engineering management." In: *Frontiers of Engineering Management* 4.1, p. 67. DOI: 10.15302/J-FEM-2017006

Wang, Yingli, Jeong Hugh Han, and Paul Beynon-Davies (2018). "Understanding blockchain technology for future supply chains: a systematic literature review and research agenda." In: *Supply Chain Management: An International Journal* 1.103, p. 2. DOI: 10.1108/SCM-03-2018-0148

Wang, Yingli, Meita Singgih, Jingyao Wang, and Mihaela Rit (2019). "Making sense of blockchain technology: How will it transform supply chains?" In: *International Journal of Production Economics* 211, pp. 221–236. DOI: 10.1016/j.ijpe.2019.02.002

Waters, C. Donald J. (2003). *Logistics. An introduction to supply chain management*. Basingstoke: Palgrave Macmillan

Westerkamp, Martin, Friedhelm Victor, and Axel Küpper (2018). "Blockchain-based Supply Chain Traceability: Token Recipes model Manufacturing Processes." In: pp. 1595–1602. DOI: 10.1109/Cybermatics_2018.2018.00267

White, Gareth R.T. (2017). "Future applications of blockchain in business and management: A Delphi study." In: *Strategic Change* 26.5, pp. 439–451. DOI: 10.1002/jsc.2144

Winkelhaus, Sven and Eric H. Grosse (2020). "Logistics 4.0: a systematic review towards a new logistics system." In: *International Journal of Production Research* 58.1, pp. 18–43. DOI: 10.1080/00207543.2019.1612964

World Economic Forum (2012). *New Models for Addressing Supply Chain and Transport Risk*. Geneva

Wüst, Karl and Arthur Gervais (2018). "Do you Need a Blockchain?" In: *2018 Crypto Valley Conference on Blockchain Technology (CVCBT)*, pp. 45–54. DOI: 10.1109/CVCBT.2018.00011

Xu, Lei, Lin Chen, Zhimin Gao, Yanling Chang, Eleftherios Iakovou, and Weidong Shi (2018). "Binding the Physical and Cyber Worlds: A Blockchain Approach for Cargo Supply Chain Security Enhancement." In: *2018 IEEE International Symposium on Technologies for Homeland Security (HST)*. IEEE, pp. 1–5. DOI: 10.1109/THS.2018.8574184

Yarm, Mark (2019). *Diamond-Tracking Is a Girl's Best Friend: An Interview With Everledger's Leanne Kemp*. URL: https://breakermag.com/diamond-tracking-is-a-girls-best-friend-an-interview-with-everledgers-leanne-kemp/

Yoo, Minjae and Yoojae Won (2018). "A Study on the Transparent Price Tracing System in Supply Chain Management Based on Blockchain." In: *Sustainability* 10.11, p. 4037. DOI: 10.3390/su10114037

Zavolokina, Liudmila, Rafael Ziolkowski, and Ingrid Bauer (2020). "Management, Governance, and Value Creation in a Blockchain Consortium." In: *MIS Quarterly Executive* 19.1, pp. 1–17. DOI: 10.17705/2msqe.00022

Zheng, Zibin, Shaoan Xie, Hong-Ning Dai, and Huaimin Wang (2017). "Blockchain Challenges and Opportunities: A Survey." In: *International Journal of Electric and Hybrid Vehicles*, pp. 1–23

Zohar, Naor (2019). "Cost-adaptive load sharing for geographically distributed data center network." In: *CCF Transactions on Networking* 2.2, pp. 98–110. DOI: 10.1007/s42045-019-00020-y

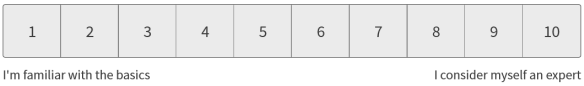
Appendices

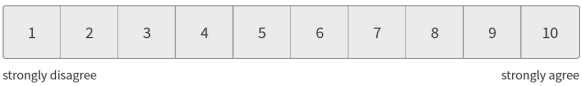
Appendix A

Scales

Table A.1: Scales Used for the Questionnaire

#	Scale
1	Familiarity —10 point Likert scale
2	Agreement —10 point Likert scale
3	Transformation —10 point Likert scale
4	Benefit —7 point Likert scale





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(Cont.) Table A.1: Scales Used for the Questionnaire

#	Scale
5	Adoption —7 point Likert scale 

Appendix B

Questionnaire

Table B.1: Questionnaire Used for the Web-Based Survey

#	Question	Scale
1	How familiar are you with logistics and supply chain processes?	Scale 1
2	How familiar are you with the Blockchain technology?	Scale 1
3	*Blockchain currently raises high expectations:* *"enormous potential" (Forbes)* *"platform for economic renewal" (Harvard Business Review)* *"holy grail" (New York Times)*	
	Do you agree with these expectations?	Scale 2
4	Who will profit from Blockchain in the logistics context? A Logistics service providers B Sender C Receiver D Consultants E Technology providers F Scientists	*Multiple choice*

continued on the next page

(Cont.) Table B.1: Questionnaire Used for the Web-Based Survey

#	Question	Scale
5	What are likely hurdles for Blockchain adoption in the logistics industry? A Regulatory uncertainty B Lack of acceptance in industry C Lack of technology maturity D Dependence on Blockchain operators E Data security concerns F Different parties/ companies would have to join forces G Benefits/ use cases are not clear	*Multiple choice*
6	If Blockchain would be implemented industry-wide in logistics, what would be the effect on established processes and business models?	Scale 3
Exemplary Use cases		
7	Exemplary Use case 1: Ease Paperwork Processing in Sea Freight	
7a	How do you evaluate the benefit of Blockchain for this usec-case?	Scale 4
7b	How likely is the adoption of Blockchain for this use case?	Scale 5
8	Exemplary Use case 2: Identify Counterfeit Products	
8a	How do you evaluate the benefit of Blockchain for this use case?	Scale 4
8b	How likely is the adoption of Blockchain for this use case?	Scale 5
9	Exemplary Use case 3: Facilitate Origin Tracking	
9a	How do you evaluate the benefit of Blockchain for this use case?	Scale 4
9b	How likely is the adoption of Blockchain for this use case?	Scale 5

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(Cont.) Table B.1: Questionnaire Used for the Web-Based Survey

#	Question	Scale
10	Exemplary Use case 4: Operating the Internet of Things	
10a	How do you evaluate the benefit of Blockchain for this use case?	Scale 4
10b	How likely is the adoption of Blockchain for this use case?	Scale 5
11	What is your company's stance toward Blockchain? A We don't look into that B We observe the development from a distance C We investigate possible use cases D We already have implemented Blockchain solutions	*Single choice*
12	Which sector do you work in? A Logistics services B Retail C Manufacturing D Consulting E Sciences	*Single choice*
13	Which country do you work in?	*Specify*
14	How many employees work in your company? A less than 250 B 250 – 3000 C more than 3000	*Single choice*

continued on the next page

(Cont.) Table B.1: Questionnaire Used for the Web-Based Survey

#	Question	Scale
15	What is your company's annual turnover? A less than $50M B $50M - $500M C more than $500M	*Single choice*
16	What is your job title?	*Specify*

Appendix C

Interview Guideline

Table C.1: Interview Guideline, final version

#	Question
	Introduction
1.	Please describe your company and your tasks within the company.
2.	How did you first encounter the Blockchain Technology? a. How would you describe Blockchain in short? b. When was your first contact with Blockchain? c. Which business processes use Blockchain?
3.	How are Blockchain efforts pursued in your company?
	Business Opportunities & Risks
4.	How do companies decide to use Blockchain? a. Why did you (not) decide for this technology? b. How do you think public opinion is relevant in this field?
5.	How do companies strategically go about implementing Blockchain? a. Which different approaches have you encountered? b. Why do companies choose which approach?
	Supply Chain Management, Logistics and Operations
6.	How has Blockchain affected the Supply Chain Management and Logistics in the industry overall? a. Which parties are publicizing this technology? b. What are simple and what are more complex use cases?
	Wrap-up
7.	What would you ask if you were to research the Blockchain technology in Supply Chain Management?
8.	Whom would you recommend to interview?

Appendix D

Interview Sample

Table D.1: Sample of the Expert Interview Study (n=24)

#	Company	Sector	Employees	Respondent Position[d]	Level of Experience[e]
1	IT solutions provider	Logistics	1-10	Director of Development	Very high
2	Consulting company	Logistics	1001-10 000	Consultant	High
3	IT solutions provider	No specific	11-100	Business Developer	Very high
4	Consulting company	Logistics	1-10	Consultant, Director	Very high
5	Bank	Trade finance	>10 000	Blockchain Business Analyst; Blockchain Identity Expert	Very high
6	Authority	Logistics	1001-10 000	Director of Business Intelligence	Medium
7	Manufacturer	Semiconductors	>10 000	Head of Supply Chain Innovations	Medium
8	Logistics service provider	Logistics	>10 000	Director of Blockchain Team	Very high
9	IT solutions provider	Conglomerate	>10 000	Engineer	Very high

[d] (multiple experts of the same company separated by semicolon) [e] (Medium: investigates use cases, High: has own proof of concepts, Very High: Blockchain is part of the core business or has conducted extensive projects)

continued on the next page

(Cont.) Table D.1: Sample of the Expert Interview Study

#	Company	Sector	Employees	Respondent position[d]	Level of Experience[e]
10	Electric utility company	Energy	>10 000	Director of Blockchain Team	Very high
11	IT solutions provider	No specific	11-100	Head of Supply Chain	Very high
12	IT solutions provider	Logistics	1001-10 000	Director of Business Development	Medium
13	Logistics service provider	Logistics (medical)	11-100	Head of Supply Chain Operations	Very high
14	Insurance	Logistics	>10 000	Head of the Legal Department	Medium
15	International trade association	Logistics	1001-10 000	Head of Digital Technology R&D	High
16	Manufacturer	Conglomerate	>10 000	Senior Developer	High
17	Logistics service provider	Ocean Freight	>10 000	Business Intelligence Analyst	Medium

[d] (multiple experts of the same company separated by semicolon) [e] (Medium: investigates use cases, High: has own proof of concepts, Very High: Blockchain is part of the core business or has conducted extensive projects)

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(Cont.) Table D.1: Sample of the Expert Interview Study

#	Company	Sector	Employees	Respondent position[d]	Level of Experience[e]
18	Manufacturer	Telecommunications equipment	>10 000	Head Manager	Medium
19	Logistics service provider	Logistics (infrastructure)	1001-10 000	IT Manager	Medium
20	Logistics service provider	Logistics	1-10	Chief Operations Office	Very high
21	Manufacturer	Automobiles	>10 000	Business Development Manager	Very high
22	IT solutions provider	Logistics	1-10	Chief Executive Officer	Very high
23	IT solutions provider	Logistics	1-10	Chief Procurement Officer; Chief Financial Officer	Very high
24	Research	-	1001-10 000	Researcher	High

Blockchain is an emerging technology concept that could be a tool to solve end-to-end integration of material and information flow in supply chain and logistics (SC&L). In this book, you can find three complementary studies on the adoption of Blockchain solutions in SC&L: (1) an analysis of existing use cases in the literature, (2) a 153-response survey outlining expectations for Blockchain in SC&L, and (3) an exploratory, qualitative Grounded Theory study that derives observations on adoption motivations, paths, barriers, and learnings. Blockchain solutions could become a valuable infrastructure tool for SC&L aligning supply chain partners worldwide.

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