

**A Framework for Enabling Asset Tokenization Business Models
in the Financial Services Sector**

DISSERTATION
of the University of St.Gallen,
School of Management,
Economics, Law, Social Sciences,
International Affairs and Computer Science,
to obtain the title of
Doctor of Philosophy in Management

submitted by

Roger Heines

from

Germany

Approved on the application of

Prof. Dr. Reinhard Jung

and

Prof. Dr. Rainer Alt

Dissertation no. 5282

Difo-Druck GmbH, Untersiemaun 2023

The University of St.Gallen, School of Management, Economics, Law, Social Sciences, International Affairs and Computer Science, hereby consents to the printing of the present dissertation, without hereby expressing any opinion on the views herein expressed

St.Gallen, October 24, 2022

The President

Prof. Dr. Bernhard Ehrenzeller

Abstract

Distributed ledger technology enables a new way to record transactions and thus fundamentally changes how ownership of digital objects can be managed in the future. In addition to various innovative application areas, the concept of tokenization has emerged in recent years, where any type of asset or contractual right can be digitally represented on a distributed ledger in the form of a token. Once this reference is established, the issuance, transfer, and storage of tokens on such decentralized platforms offers not only the opportunity for increased operational efficiencies but also for new innovative services.

Especially in the financial industry, the interest in the tokenization of bankable assets is growing. However, little is empirically known about this concept, its benefits, and its realization. Further, it can be stated that previous research solely focuses on technological or conceptual problems and that an integrative perspective on this phenomenon has been neglected so far. While companies are encouraged to establish unique business models around technological innovation, a blueprint with insights into applicability, design, and implementation is required.

This dissertation addresses this gap by providing a first reference point to enable business model innovation for asset tokenization in the financial services sector. In particular, a frame of reference with three respective artifacts was developed to determine the business potential of tokenization, enable the design of its value architecture, and highlight guiding principles for its successful implementation. The work follows a design-oriented paradigm in terms of design science research and aims at a scientifically sound foundation for practice and academia. While asset tokenization may disrupt our economic system leading to more efficiency and accessibility, this research provides strategic guidance in a token economy and may accelerate the development of viable use cases and business models in the future.

Zusammenfassung

Die Distributed Ledger Technologie ermöglicht es, Transaktionen mit einem neuen technischen Ansatz aufzuzeichnen und verändert damit grundlegend, wie Eigentumsnachweise an digitalen Objekten in Zukunft verwaltet werden können. Neben verschiedenen Anwendungsbereichen der Technologie, hat sich daher in letzten Jahren das Konzept der Tokenisierung etabliert, bei dem jegliche Art von Vermögenswert oder vertragliches Recht in Form eines Tokens in dezentral geführten Kontobüchern digital abgebildet werden kann. Folglich bietet die Ausgabe, Übertragung und Speicherung von Token auf diesen dezentralen Plattformen nicht nur die Möglichkeit, die betriebliche Effizienz zu steigern, sondern auch neue innovative Dienstleistungen zu erstellen.

Obwohl die Finanzindustrie bereits die Tokenisierung von traditionellen Vermögenswerten in der Theorie erwägt, ist wenig über das Konzept, den Nutzen und dessen Umsetzung bekannt. Darüber hinaus kann festgestellt werden, dass sich die bisherige Forschung ausschliesslich auf technologische oder konzeptionelle Probleme konzentriert und eine integrative Perspektive auf dieses neue Phänomen vernachlässigt. Um Unternehmen zu ermutigen, einzigartige Geschäftsmodelle rund um technologische Innovation zu etablieren, sind daher Einblicke in die Anwendung und Ausgestaltung dieses Konzeptes erforderlich.

Die vorliegende Dissertation schliesst diese Lücke, indem sie einen ersten Bezugspunkt für Geschäftsmodellinnovation im Rahmen der Tokenisierung von Vermögenswerten im Finanzdienstleistungssektor bietet. Der Referenzrahmen basiert auf drei Artefakten, welche die Geschäftspotenziale der Tokenisierung, die Ausgestaltung einer Geschäftsarchitektur und Organisationsprinzipien für eine erfolgreiche Umsetzung aufzeigen. Die Arbeit folgt dem Paradigma der gestaltungsorientierten Forschung und liefert damit eine wissenschaftlich fundierte Grundlage für die Theorie und Praxis. Diese Forschung leistet einen ersten Beitrag für die geschäftsorientierte Gestaltung in einer Token-Ökonomie und kann dadurch die Entwicklung von praktikablen Anwendungsfällen und Geschäftsmodellen beschleunigen.

Overview of Contents

OVERVIEW OF CONTENTS	I
TABLE OF CONTENTS	II
LIST OF FIGURES	VII
LIST OF TABLES	IX
ABBREVIATIONS	XI
1 INTRODUCTION	1
2 RESEARCH BACKGROUND	21
3 THE BUSINESS POTENTIAL OF ASSET TOKENIZATION	62
4 A CONCEPTUAL MODEL FOR ASSET TOKENIZATION	93
5 ORGANIZATIONAL PRINCIPLES FOR IMPLEMENTATION	181
6 DISCUSSION AND CONCLUSION	207
REFERENCES	216
GLOSSARY	251
APPENDICES	259
CURRICULUM VITAE	287

Table of Contents

Overview of Contents	I
Table of Contents	II
List of Figures	VII
List of Tables.....	IX
Abbreviations	XI
1 Introduction	1
1.1 Motivation.....	1
1.2 Research Objective and Research Questions.....	7
1.3 Contribution and Target Audience	10
1.4 Research Approach	12
1.4.1 Design Science Research	13
1.4.2 Consortium Research	14
1.4.3 Research Methods.....	16
1.5 Structure of the Dissertation	19
2 Research Background.....	21
2.1 Distributed Ledger Technology.....	21
2.1.1 Introduction to Distributed Ledgers.....	21
2.1.2 Cryptocurrencies.....	25
2.1.3 Smart Contracts	27
2.1.4 Types of Distributed Ledgers.....	29
2.2 Asset Tokenization	32
2.2.1 Concept of Tokenization	32
2.2.2 Token-based Business Models.....	35
2.3 Financial Intermediation.....	36
2.3.1 Functions of Financial Intermediaries	37
2.3.2 Transfer of Assets.....	39

2.4	Business Model Research	40
2.4.1	Concept and Definition	40
2.4.2	Business Model Components	42
2.4.3	Business Model Innovation	44
2.5	Technology-Organization-Environment Framework	47
2.5.1	The Framework and its Elements	47
2.5.2	Applicability of the Framework in Research	49
2.6	Literature Review and Research Gap	50
2.6.1	Problem Definition	51
2.6.2	Scope of the Review	53
2.6.3	Conceptualization of the Topic	54
2.6.4	Literature Search	55
2.6.5	Literature Analysis and Synthesis	57
2.6.6	Research Agenda	59
2.7	Chapter Summary	60
3	The Business Potential of Asset Tokenization	62
3.1	Overview of Related Work	62
3.1.1	Token Classifications	63
3.1.2	Application Areas of Tokenization	65
3.2	Development of the Assessment Framework	67
3.2.1	First Iteration	68
3.2.2	Second Iteration	69
3.2.3	Third Iteration	71
3.3	Assessment Framework for Asset Tokenization	72
3.3.1	Token Properties	73
3.3.2	Drivers of Tokenization	75
3.3.3	Barriers of Tokenization	76
3.3.4	Assessment of Tokenization Use Cases	78

3.4	Archetypical Use Cases of Asset Tokenization	81
3.4.1	Empirical Analysis	81
3.4.2	Patterns between Properties, Drivers, and Barriers ...	82
3.4.3	Asset Tokenization Archetypes	86
3.4.3.1	Programmable Money	87
3.4.3.2	Smart Bankable Assets	88
3.4.3.3	Opening of Illiquid Assets	88
3.4.3.4	Crowd Financing	89
3.4.3.5	Service Access	89
3.4.3.6	Platform Governance	90
3.4.3.7	Digital Sovereignty	91
3.4.3.8	Track and Trace	91
3.5	Chapter Summary	92
4	A Conceptual Model for Asset Tokenization	93
4.1	State of the Art	93
4.1.1	Foundational Modeling Approaches	93
4.1.2	DLT-based Architecture Frameworks	98
4.1.3	Discussion on Related Approaches	105
4.2	Case Studies	107
4.2.1	Case Study Selection	107
4.2.2	Case Study Summaries	109
4.2.2.1	Amazing Blocks	110
4.2.2.2	TokenX	111
4.2.2.3	Berner Kantonalbank and Daura	112
4.2.2.4	NYALA	113
4.2.2.5	SIX Group	114
4.2.2.6	Bank Frick	115
4.2.3	General Findings	116

4.3	Modeling Approach.....	117
4.3.1	Design Requirements	119
4.3.2	Conceptualization	121
4.3.3	Iterative Design Cycles	123
4.4	Conceptual Model Description.....	125
4.4.1	Model Overview	125
4.4.2	Network.....	129
4.4.2.1	Network Roles.....	130
4.4.2.2	Network Governance	135
4.4.3	Processes	143
4.4.4	Services	147
4.4.5	Technology	153
4.4.6	Environment.....	160
4.5	Practical Application	163
4.5.1	The Case of BEKB.....	164
4.5.2	The Case of NYALA	168
4.5.3	Analysis and Implications	173
4.6	Evaluation	175
4.6.1	Process and Overview.....	176
4.6.2	Requirements Fulfilment.....	177
4.7	Chapter Summary.....	180
5	Organizational Principles for Implementation	181
5.1	Impact of Decentralization on the Organization.....	181
5.2	Identification of Challenges and Solutions.....	184
5.2.1	Literature Review	185
5.2.2	Expert Interviews	186
5.2.3	Impact Mapping	187

5.3	Challenges and Affected Business Services	188
5.3.1	Impact of Technology on the Organization	189
5.3.1.1	Administration and Coordination.....	190
5.3.1.2	IT System Engineering	191
5.3.1.3	User-centered Application Design	193
5.3.2	Impact of the Organization on Itself.....	194
5.3.3	Impact of the Environment on the Organization	196
5.3.3.1	Governance	197
5.3.3.2	Revenue.....	199
5.4	Principles to Guide Organizational Change.....	201
5.5	Chapter Summary.....	205
6	Discussion and Conclusion.....	207
6.1	Summary of Results	207
6.2	Contributions to the State of the Art	210
6.3	Limitations and Further Research	212
	References	216
	Glossary	251
	Appendices	259
	Appendix A: DLT Basics	260
	Appendix B: Artifact Design Process Overview.....	263
	Appendix C: Focus Group Meetings.....	266
	Appendix D: Asset Tokenization Framework	270
	Appendix E: Conceptual Model	275
	Appendix F: Organizational Principles.....	281
	Curriculum Vitae	287

List of Figures

Figure 1-1: Literature analysis on tokenization and associated terms .	6
Figure 1-2: The frame of reference of the dissertation	8
Figure 1-3: DSR-approach following Hevner (2007, p. 2)	14
Figure 1-4: Consortium research following Österle & Otto (2010, p. 278)	15
Figure 1-5: Structure of the dissertation	20
Figure 2-1: Centralized and distributed databases (Alt, 2021, p. 3)...	22
Figure 2-2: Intensional and extensional definitions of tokenization	33
Figure 2-3: Cryptoassets and associated concepts	35
Figure 2-4: Scope of asset tokenization business models	36
Figure 2-5: Functional context of financial intermediation (Bernet, 2003, p. 18).....	39
Figure 2-6: Clearing & settlement process (Guadamillas & Keppler, 2001, p. 6)	40
Figure 2-7: Phases of the business model innovation process and their key challenges (Frankenberger et al., 2013, p. 264).....	46
Figure 2-8: The TOE framework (Tornatzky & Fleischer, 1990, p. 154)	47
Figure 2-9: Literature review following Vom Brocke et al. (2009, p. 8).....	51
Figure 2-10: Review scope following Cooper (1988, p. 109)	53
Figure 2-11: Initial conceptualization of the research topic	54
Figure 2-12: Literature analysis and thematic coverage of the research topic	59
Figure 3-1: Exemplary token properties for the tokenization of a classic car	79
Figure 3-2: Exemplary drivers and barriers for the tokenization of a classic car	80

Figure 3-3: Archetypes of asset tokenization (Heines, Dick, et al., 2021, p. 9)	86
Figure 4-1: Business Engineering (Österle & Winter, 2003, p. 12)	96
Figure 4-2: Excerpt from blockchain-related design decisions regarding blockchain configurations by Xu et al. (2017, p. 249)	101
Figure 4-3: Architecture for BC-certification (Abreu et al., 2020, p. 154)	103
Figure 4-4: Market Engineering Framework (Notheisen et al., 2017, p. 1073).	104
Figure 4-5: Modeling approach following Peffer et al. (2007, p. 11)	117
Figure 4-6: Model overview and respective elements	126
Figure 4-7: Overview of network governance.....	137
Figure 4-8: Control versus value of DLT (Conway & Garimella, 2020, p. 29)	140
Figure 4-9: Macro and sub-process of asset tokenization.....	144
Figure 4-10: Overview of service cluster and service offerings.....	148
Figure 4-11: Overview of technological elements	154
Figure 4-12: Overview of the environment	160
Figure 4-13: Simplified application of the conceptual model	163
Figure 4-14: Adapted network roles for the case of BEKB.....	165
Figure 4-15: BEKB sub-processes for asset tokenization	166
Figure 4-16: BEKB services and service cluster	167
Figure 4-17: Adapted network roles for the case of NYALA.....	169
Figure 4-18: NYALA sub-processes for asset tokenization.....	170
Figure 4-19: NYALA services and service cluster	171
Figure 4-20: NYALA technology layer	172
Figure 5-1: Impact of technology on the organization	189
Figure 5-2: Impact of the organization on itself	194
Figure 5-3: Impact of the environment on the organization.....	196

List of Tables

Table 1-1: Target audience and benefits.....	12
Table 2-1: DLT typology (Beck et al., 2018, p. 8).....	30
Table 2-2: Comparison of DLT designs and their features.....	31
Table 2-3: Description of meta-requirements and selected responses	52
Table 2-4: Results of the literature search process	56
Table 3-1: Overview of interviews	70
Table 3-2: The assessment framework (Heines, Dick, et al., 2021, p. 6)	72
Table 4-1: Research streams on DLT and BC-based conceptualizations	99
Table 4-2: Design requirements based on content-driven criteria ...	120
Table 4-3: Design requirements based on quality-driven criteria	121
Table 4-4: Results of the literature search process	122
Table 4-5: Overview of case studies and design of elements	124
Table 4-6: Overview of tokenization value chain roles	131
Table 4-7: Overview of DLT-based platform roles.....	132
Table 4-8: Overview of DLT-based technical roles	133
Table 4-9: Overview of DLT-based system roles	135
Table 4-10: Network governance perspective	138
Table 4-11: Network governance dimensions	139
Table 4-12: Sub-categories of network governance dimensions	142
Table 4-13: Network governance system scope	143
Table 4-14: Macro processes and related activities	145
Table 4-15: Sub-processes and related activities	146
Table 4-16: Verification and authentication services	149
Table 4-17: Node services.....	150
Table 4-18: Platform services.....	150

Table 4-19: Token services	152
Table 4-20: Support services.....	152
Table 4-21: Application layer	155
Table 4-22: API layer	156
Table 4-23: DLT protocol layer	157
Table 4-24: DLT network layer	157
Table 4-25: DLT data layer	158
Table 4-26: Physical layer	159
Table 4-27: Qualitative evaluation of content-driven criteria	178
Table 4-28: Semi-quantitative evaluation of quality-driven criteria...	179
Table 5-1: Extant research streams on the impact of DLT on organizations	183
Table 5-2: Results of the literature search process	185
Table 5-3: Overview of interviews (Heines, Kannengießer, et al., 2021, p. 3).....	187
Table 5-4: Principles for organizational change in DLT implementation	202

Abbreviations

AML	Anti Money Laundering
API	Application Programming Interface
B2B	Business-to-Business
B2C	Business-to-Consumer
BaFin	Federal Financial Supervisory Authority
BC	Blockchain
BE	Business Engineering
BIAN	Banking Industry Architecture Network
BISE	Business and Information System Engineering
CBDC	Central Bank Digital Currency
CC	Competence Center
CCP	Central Counterparty
CSD	Central Securities Depository
DAG	Directed Acyclic Graph
DAO	Decentralized Autonomous Organization
DApp	Decentralized Applications
DBMS	Database Management System
DeFi	Decentralized Finance
DEX	Decentralized Exchange
DLT	Distributed Ledger Technology
DSR	Design Science Research
DVP	Delivery Versus Payment
EDI	Electronic Data Interchange
ERC	Ethereum Request for Comments
FINMA	Swiss Financial Market Supervisory Authority
GDPR	General Data Protection Regulation
GUI	Graphical User Interface
ICO	Initial Coin Offering
IoT	Internet of Things
IPFS	InterPlanetary File System

IS	Information Systems
IT	Information Technology
KYC	Know Your Customer
MR	Meta-Requirement
NFC	Near Field Communication
NFT	Non-Fungible Token
OCR	Optical Character Recognition
OSI	Open Systems Interconnection
OTC	Over-the-Counter
P2P	Peer-to-Peer
PKI	Public Key Infrastructure
PoS	Proof of Stake
PoW	Proof of Work
RFID	Radio-Frequency Identification
RO	Research Objective
RQ	Research Question
SDK	Software Development Kit
SME	Small and Medium-Sized Enterprise
SPV	Special Purpose Vehicle
STO	Security Token Offering
SWIFT	Society for Worldwide Interbank Financial Telecommunication
TOE	Technology Organization Environment
UML	Unified Modeling Language
UTXO	Unspent Transaction Output
WG	Working Group
WS	Workshop

1 Introduction

“As for the future, your task is not to foresee it but to enable it.”

(Antoine de Saint-Exupéry)

1.1 Motivation

Blockchain (BC) and its underlying distributed ledger technology (DLT) brought a new architectural paradigm for information systems (IS) to operate highly available, tamper-resistant distributed databases for transactions (Beck et al., 2017). Fully implemented in 2008 as peer-to-peer electronic cash based on the Bitcoin protocol, it allowed for the first time the transfer of a digital currency directly from one user to another without relying on mediation by trusted third parties like banks (Nakamoto, 2008). Since then, this innovation has created significant attention by establishing a new kind of trust and authenticity in the digital realm for countless potential use cases across industries, such as electronic contracts, e-health records, digital identities, micropayments, or track and trace (Swan, 2015).

Besides various application areas, the concept of *tokenization* has emerged in the financial services sector in recent years. The concept follows DLT's key characteristics and describes an innovative approach for managing asset ownership of digital representations (Hrga et al., 2020). In particular, tokenization refers to the process of creating a unique singular identifier on a distributed ledger in the form of a token that may digitally represent anything from valuable objects (e.g., artwork) or contractual rights (e.g., ownership right) (Distefano et al., 2020; Harwood-Jones, 2019). Once this reference is established, it is assumed that the issuance, transfer, and storage of tokens on DLT-based platforms reduce drawbacks of intermediaries, such as single points of failure or lagging processing times. Especially the digital representation of bankable assets in terms of stocks and bonds has become a promising use case for tokenization. The existing financial market infrastructures may benefit from widespread implications on efficiency,

accessibility, transparency, liquidity, and disintermediation (OECD, 2020). Accordingly, the Financial Times estimates that DLT-based platforms may save asset managers up to \$2.7 billion per year just in the process of buying and selling funds (Mooney, 2018). In addition, the concept may not only affect existing business models in the financial services sector. While tokenization enables a fundamentally new way of recording transactions and transferring value, it can serve as an enabler for new services in a novel type of economy, a so-called *token economy*, and allows frictionless collaboration and interaction across various industries (Sunyaev et al., 2021). Although the feasibility of asset tokenization has been demonstrated in the financial industry, adoption has not kept pace with the number of announced projects and investments (Grilo & Zutshi, 2020). While Hughes et al. (2019) state that missing technical standards lead to use cases stuck at the prototyping phase, Hartung et al. (2019) assume that new regulatory frameworks are necessary to achieve commercialization.

As an enabler for transforming existing business models and establishing new ones, the potentials for product and service innovation seem endless for decision-makers. Tokenization can be utilized for many purposes in a system and is not primarily limited to tradable objects. In logistics, for example, unique tokens could be used to track and trace pharmaceuticals for a more transparent product lifecycle (Madhwal, 2020). Service access might be restricted, letting a token holder use a car-sharing platform once a specific token is acquired. Companies can issue limited tokens for licensing digital content or other digitized resources (Zhou et al., 2019). While everything from art, diamonds, real estate, even oceans or stars may be tokenized and digitally represented on DLT-based platforms, questions about the business potential of specific use cases arise. Practitioners must align their activities by identifying both opportunities and risks of a DLT-project (Naqvi, 2020). Most notably, insights are needed on the applicability of specific tokenized objects (e.g., bankable assets, physical objects), their drivers (e.g., increased liquidity, transparency), and barriers to adoption (e.g., regulation, data privacy). Oliveira et al. (2018) highlight the complexity of requirements for DLT-based token design, where the industry faces all

sorts of token classifications, either from a regulatory or technical perspective. Terms such as *digital assets*, *cryptocurrencies*, or *coins* are often interchangeably used (Harwood-Jones, 2019). Existing decision-support tools (e.g., token standards) lack strategic guidance for successful use case identification and ideation. Aside from descriptive token taxonomies in this rapidly evolving field, recent IS research lacks a framework that considers these factors and defines the unique business potential of tokenization in the context of different asset classes.

In addition to unknown business potentials, it is also assumed that current practices and principles cannot guide companies through the necessary strategic, processual, and technological changes to operationalize asset tokenization and successfully scale such DLT-based platforms. Guidance is especially required for business architects who want to plan and design such innovative infrastructures. For example, DLT relies on a network of separate computing devices, so-called nodes that interact without mediation and involvement of a central party (Kannengießer, Lins, Dehling, et al., 2020). Management is distributed across participating companies in the network, leading to a different paradigm for architectures beyond conventional electronic data interchange (EDI) (Heines, Kannengießer, et al., 2021). Therefore, the distributed logic of DLT (cf. smart contracts) not only provides the ability to share data between entities but also enables shared process models to facilitate collaboration (Rauchs et al., 2018).

Moreover, it can be stated that traditional market infrastructures may represent a barrier to continued adoption. For example, a reassessment of established governance structures might be necessary, where asset tokenization may lead to fewer intermediaries (Beck et al., 2018). Despite the benefits of tokenizing bankable assets, new platforms are likely to compete with highly compliant legacy systems, posing a transition risk to established value chains. In these cases, Hartung et al. (2019) discuss entry barriers for transforming existing business models in the financial services sector, highlighting the integration efforts for existing core banking systems, processes, and services. When designing business models related to asset tokenization, decision-makers

need to ensure that the transformation is aligned with the company's strategic goals and operational capabilities.

For an efficient design, a blueprint is needed that provides an overview of the relevant elements such as the value network, functional structures, processes, technology, and information resources (Reitbauer et al., 2008). Nevertheless, existing research remains scarce and shows shortcomings in modeling holistic aspects from an integrative perspective. The approaches focus on generic elements of DLT and- BC-based platforms or describe specific technical architectures for adoption. While Riasanow et al. (2018) highlight, for instance, the different roles within a BC ecosystem, Ross et al. (2019) identify the technical requirements of a decentralized platform for post-trade processing. It is still unclear how to model and conceptualize asset tokenization as part of a broader business model. A common understanding for practitioners from a strategic, operational, and technical perspective is appreciated to fully realize innovative services and use cases in the long run.

However, implementing such decentralized platforms has multiple implications for the financial service firm on an intra-organizational level. DLT introduces technical and organizational challenges that require new competencies across different business functions (Mendling et al., 2018). For the effective delivery of new services in token-based business ecosystems¹, it is assumed that organizational change has to be initiated involving not only technology but also people and processes. Regarding the scope of business model transformation, these changes may even lead to a reorganization of the company's organizational structure (Sauer et al., 1997). A token economy reduces information asymmetries and can support the development of flat organizations instead of hierarchical ones (Sunyaev et al., 2021). A thorough understanding of the potential challenges of DLT-based decentralized platforms is required to anticipate organizational change. For effective decision-making, it is still unknown which internal factors might become subject to transformation. Sternberg et al. (2021) discuss obstacles to

¹ In this work, business ecosystems refer to dynamic structures of independent actors (e.g., business networks) that coordinate their activities to satisfy customers need (cf. Moore, 1993).

BC adoption, particularly in a supply chain's inter-organizational settings, and identify external factors such as the lack of network effects and required governance mechanisms. Research on the intra-organizational perspective remains scarce and investigates generic relationships between operational abilities, processes, and settings internal to a company (Seebacher et al., 2021). Within this area, integration in business processes is an important issue that demonstrates the importance of improving organizational competencies for successful implementation (Cen et al., 2017; Mendling et al., 2018). So far, no overview indicates the required transformations of business functions to initiate business model change successfully.

As an innovative concept, the interest in asset tokenization is consistently growing and draws increasing attention in various industries (Sazandrishvili, 2020). This momentum is not only reflected by the surge of grey literature but is most notably driven by multiple pilot projects and initiatives. A descriptive literature analysis of tokenization and its surrounding areas has been conducted to underline the topic's relevance and importance. Following the recommendations for literature search by Vom Brocke et al. (2009), the results have also been elaborated in Section 2.6 to highlight the current state of related work and determine the underlying research gap.

Tokenization creates a digital representation of value or contractual rights in terms of a token and follows the functionalities of cryptocurrencies to be issued, stored, and traded electronically via a DLT (Distefano et al., 2020). For the search process in August 2021, the terms *tokenization*, *cryptocurrencies*, *assets*, and *token* in the context of *blockchain* and *distributed ledger technology* have been included using several scientific databases, such as EBSCOhost, IEEE Xplore, AIS eLibrary, Science Direct, ProQuest, and ACM. After prioritizing terms and excluding duplicates, the analysis revealed 1954 publications in total. This amount represents almost half of all BC and DLT-related research items, with a total of 4027 hits. The year wise-analysis in Figure 1-1 shows that it took several years after the invention of Bitcoin before the interest rapidly increased. Since then, the numbers have been consistently

growing, with more than 35% of all sources published in 2020. It seems logical that the first research papers on *cryptocurrencies* were published due to the early adoption of Bitcoin. While *assets* in the context of BC and DLT are often synonymously referred to as *cryptoassets*, the research output strongly aligns with the prevailing interest in *cryptocurrencies*. Research on *tokens* rose significantly around 2018, and publications almost tripled in 2020. Accordingly, it is assumed that the technical development of token standards set the basis for more academic relevance, and the research interest was further accelerated during the hype of initial coin offerings (ICO) at the beginning of 2018. Tokenization, however, represents a novelty in academia that first appeared at the end of 2017. While research remains scarce, this concept is expected to gain momentum as the number of publications in the first half of 2021 already exceeds the previous year's results.

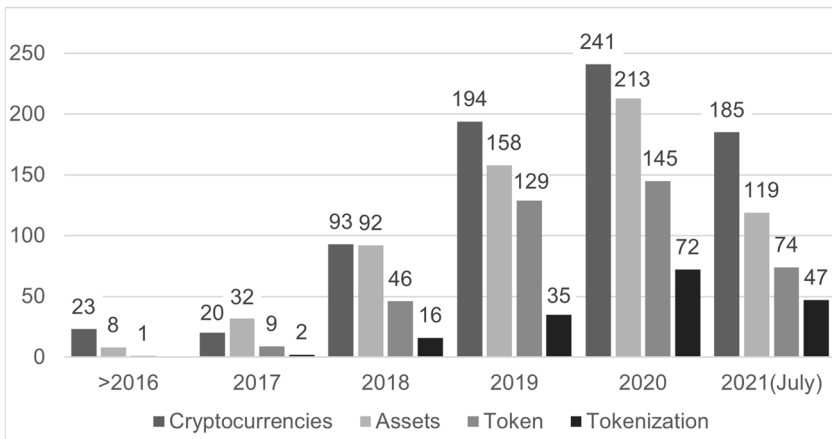


Figure 1-1: Literature analysis on tokenization and associated terms

As the descriptive literature analysis already reveals a steady trend on this topic, it can be assumed that new insights in this innovative field are appreciated. For that reason, developing a framework for enabling asset tokenization business models represents a promising area of research to accelerate the widespread adoption and contribute to practice and academia by providing a holistic foundation for ideation, design, and implementation.

1.2 Research Objective and Research Questions

Despite widely discussed benefits and opportunities in the financial services sector, little is empirically known about the concept of asset tokenization to increase value creation and unlock new market potentials. While companies are improving and developing novel products and services, they are typically encouraged to design unique business models around technological innovation to realize their full commercialization (Zott et al., 2011). This work addresses this topic and serves as a first reference point for academia and practice to understand why the concept of asset tokenization should be addressed and how design and implementation can be approached. Given the practical need and underlying research gap of this evolving phenomenon, the following overarching research objective (RO) has been defined:

RO: Development of a framework to enable asset tokenization business models in the financial services sector

This dissertation aims at a frame of reference based on three primary outcomes shown in Figure 1-2 that support business model innovation in the financial services sector. Firstly, the framework allows to assess the business potential of tokenization and illustrates how firms can apply use cases within the context of different token properties, drivers, and barriers for adoption. Secondly, it provides a set of elements to design a conceptual architecture for value creation in asset tokenization business models. Lastly, it offers organizational principles for implementing such DLT-based decentralized platforms in the financial services sector. Following Zachman (1987), an *IS framework* rationalizes concepts and specifications for clarity of communication and establishes credibility for investments of systems resources. As a result, knowledge about this concept is created that meets several design-oriented requirements from a strategic and operational perspective. For business model theory, this work further contributes to the current body of knowledge by complementing existing modeling approaches and specifying components for the successful realization of this innovation.

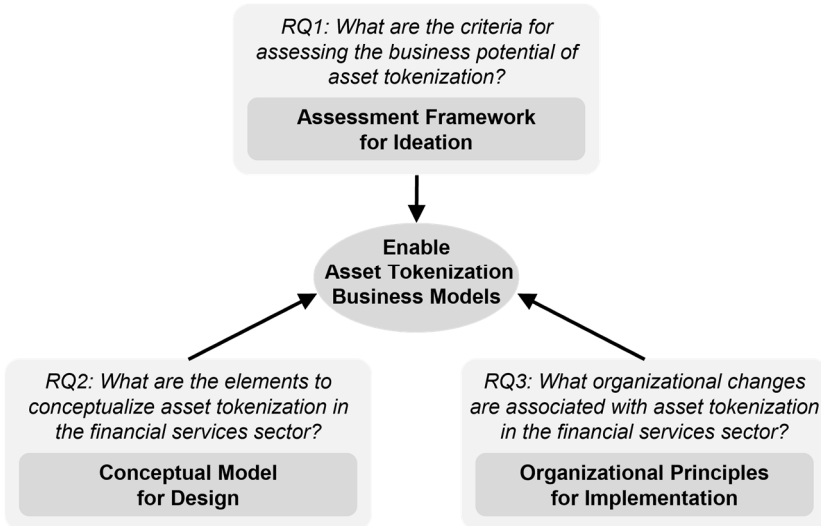


Figure 1-2: The frame of reference of the dissertation

The dissertation follows a design-oriented research paradigm anchored in design science research, where the outcome is represented by artifacts (Hevner et al., 2004). Regarding the overarching objective, the results are further decomposed into three research questions (RQ):

RQ1: What are the criteria for assessing the business potential of asset tokenization?

Tokenization has become a growing phenomenon with various use cases that may disrupt our economic system beyond the tokenization of bankable assets (Sazandrishvili, 2020). However, the complexity of different token designs and the lack of a common approach exacerbates an assessment of applicability. To illustrate how firms can apply tokenization to innovate their businesses, RQ1 addresses a classificatory framework to determine the potential of use cases in a given scenario. According to March & Smith (1995), the results are structured in a model and provide assessment criteria such as token properties, drivers, and barriers for adoption. Besides a literature review, expert interviews, and focus group meetings, a database of 129 tokenization ventures is sampled to derive eight archetypical use cases. By extending

knowledge beyond token design, the artifact supports the firm's decision-making process for use case ideation and sets a starting point for developing viable applications in a token economy.

RQ2: What are the elements to conceptualize asset tokenization in the financial services sector?

An introduction of asset tokenization in the financial services sector can have significant implications for established market infrastructures, existing processes, and systems (Hartung et al., 2019). Especially after the prototyping and pilot phase, a holistic blueprint that ensures integration and transition is still unexplored. To provide a conceptual foundation for practitioners, RQ2 aims at a set of elements that allows the design of a holistic value architecture for asset tokenization. The artifact represents a model which specifies and describes different layers such as network roles, governance, processes, services, systems, and environmental factors. Based on secondary and primary data gathered through multiple case studies, literature reviews, and surveys, the elements include different overviews, building blocks, definitions, and architectural considerations from a managerial and technical view.

RQ3: What organizational changes are associated with asset tokenization in the financial services sector?

Asset tokenization is a transformative paradigm highly expected to revolutionize financial market infrastructures in various ways (Harwood-Jones, 2019). However, the implementation of asset tokenization business models and DLT-based platforms leads not only to technical but also to organizational challenges. To generate knowledge about the implications and the impact on the individual firm, RQ3 refers to the development of organizational principles that anticipate internal transformation, mitigate risks, and facilitate DLT implementation. The outcome is based on an instantiation, where challenges caused by DLT were investigated during a literature review and interview study. By mapping these challenges to internal business functions, organizational change and corresponding solutions are identified. Finally, the results are

evaluated and prioritized in focus group meetings to conclude applicable principles in the form of eight actionable guidelines.

1.3 Contribution and Target Audience

This work provides a novel contribution to one of the most promising application areas of BC and DLT. It generates new insights regarding the business potential, the architecture of value creation, and organizational changes to support ideation, design, and implementation of asset tokenization business models. Accordingly, the frame of reference with its three respective artifacts may serve as a foundation to extend understanding of purposeful decision-making and complement existing approaches for successful adoption in the financial services sector. In line with the research questions and proposed artifacts, the contribution is further based on three main results.

Assessment framework for ideation: To create a competitive advantage for companies, Teece (2010) highlights the need to fully understand the applicability of new technologies. Accordingly, this artifact allows strategists and managers to determine the business potential of different asset tokenization use cases based on predefined assessment criteria (cf. token properties, drivers, and barriers for adoption). In addition, archetypical use cases provide an overview of existing solutions and extend the knowledge for interdisciplinary applications in other industries. In practice, the framework may be utilized as a decision-aid tool to compare viable solutions for different tokenized objects and help to illustrate how firms can enter this highly innovative area. For academia, the research generates new empirical insights about existing use cases and may foster the investigation of viable industry applications in a token economy besides cryptocurrencies.

A conceptual model for design: Without a central instance for managing asset ownership, DLT significantly differs from conventional systems, leading to new functions, services, and actors for operating token-based decentralized platforms (Sunyaev et al., 2021). By addressing and modeling such aspects, the second artifact enables business

architects and technical consultants to design a conceptual architecture for value creation in asset tokenization business models. In addition, it establishes an understanding of a complex system with varying levels of abstraction and illustrates how the firm delivers value. In practice, it might also complement existing business architecture frameworks or serve as an entry point for a target operating model. The contribution to research focuses on methodological support for a potential class of other models or formalized architectures with a higher degree of granularity. Finally, the identified elements represent a foundation for empirical research to identify patterns or derive design knowledge for novel DLT-based platforms.

Organizational principles for implementation: It is assumed that DLT-implementation leads to challenges that require organizational change. The third artifact addresses this gap and provides a first overview of critical aspects beyond technical factors. Based on the BIAN service landscape (BIAN, 2019), the illustrated impact on business functions allows strategists and managers to specify the transformational need and convince the firm of the necessary business model change. In addition, the presented organizational principles represent a set of best practices to overcome internal resistance and prepare practitioners to successfully implement and operate decentralized services associated with asset tokenization. For academia, the results extend the perspective on intra-organizational implications of DLT-based platforms and serve as a starting point to further investigate transformative mechanisms for other industries and application areas.

The intended audience of the proposed dissertation relates to both academics and practitioners. On one side, the result addresses scholars with an emphasis on business and information system engineering (BISE) and researchers from associated domains, such as management, system, and service science. On the other side, mainly practitioners from the service industry in innovation, IT, strategy, management, and other related fields are addressed. The practical contribution is dependent on the individual results and may also vary for a particular target audience, as shown in Table 1-1.

Scope	Target Audience	Benefits
RO1: Assessment Framework for Ideation (Model)	Practitioners in the service industry from the areas of innovation, (IT) strategy, and (asset) management	The framework supports practitioners in identifying the business potential of tokenization based on different assessment criteria and archetypical use cases.
	Researchers from the BISE and management domain	The framework enables researchers to understand the potential of tokenization and foster the discussion on the business opportunities of a token economy.
RO2: Conceptual Model for Design (Model)	Practitioners in the service industry from the areas of IT, business architecture, technical consulting, and requirements engineering	The model assists practitioners in designing a conceptual architecture for value creation in asset tokenization business models.
	Researchers from the BISE and service science domain	The model enables researchers to investigate the operationalization of DLT-based platforms and develop methodological support for a new class of architectures.
RO3: Organizational Principles for Implementation (Instantiation)	Practitioners in the financial industry from the areas of innovation, (IT) strategy, and business development	The principles enable practitioners to prepare the firm for a transformation and to anticipate organizational change for a successful implementation.
	Researchers from the BISE and management domain	The principles allow researchers to focus on transformative mechanisms in other industries and develop design-oriented solution artifacts for more specific problem domains.

Table 1-1: Target audience and benefits

1.4 Research Approach

Considering the principles of good research by Bartunek et al. (2006), this section introduces the relevant methodological background to answer the research questions and meet the study's objective. The first two sub-sections introduce the concept of design science research extended by consortium research as a foundation for designing the three increments. Accordingly, the chapter closes with an overview of complementing research methods for the individual iterative cycles to ensure relevance and rigor of the research process.

1.4.1 Design Science Research

The objective of the research discipline *Wirtschaftsinformatik* (German-speaking world) and its Anglo-American equivalent *information systems research* is often associated with the analysis and development of information systems, their elements, or related theories (WKWI, 2003, p. 319). It refers to applied sciences, where it often follows a design-oriented paradigm in terms of design science research (DSR). The methodology goes back to Simon (1969) and is used in various fields (e.g., engineering, computer science, or economics). Good DSR strives for practical relevance and scientific rigor by addressing real-life problems and contributing to the existing body of knowledge for scientific discussion (Winter, 2007).

The results represent valuable artifacts based on three iterative cycles: *relevance*, *rigor*, and the *design cycle* (Hevner et al., 2004, p. 80). Accordingly, March & Smith (1995, p. 256) describe four types of research outputs while building and evaluating IS artifacts with a design science intent. Firstly, *constructs* or *concepts* are specified as subject to a description of a problem addressing and determining a solution for given research or theory-building purposes. Secondly, *models* are defined as simplified and more abstract representations of reality. They also embody a set of propositions and statements about the relationships between constructs. The third type of artifacts are *methods* based on constructs and models applied in a sequence of predefined steps. Lastly, the *instantiation* represents an operationalized scenario in a particular setup and environment.

In this research project that aims at a *framework to enable asset tokenization business models in the financial services sector*, DSR represents a suitable approach to address the research questions in terms of two models and one instantiation. DSR follows the construction and evaluation of innovative artifacts to develop a sound foundation for novel business solutions. Referring to the three iterative DSR cycles by Hevner (2007, p. 2), the generic approach shown in Figure 1-3 constitutes the basis for the research activities of the dissertation. Accordingly,

challenges and opportunities for the problem domain are identified through the *relevance cycle* to specify the objectives of the solution and define requirements for the artifact. Following the *rigor cycle*, the existing body of knowledge, such as theoretical contributions and scientific methods, is also applied to develop a grounded, robust and objective solution for the predefined problem statement. Both findings from the relevance and rigor cycle are then combined in the *design cycle* to build innovative artifacts through design, evaluation, and validation utilizing case studies, surveys, focus groups, and interviews. The sub-activities are conducted iteratively once the utility of the artifact is fully validated.

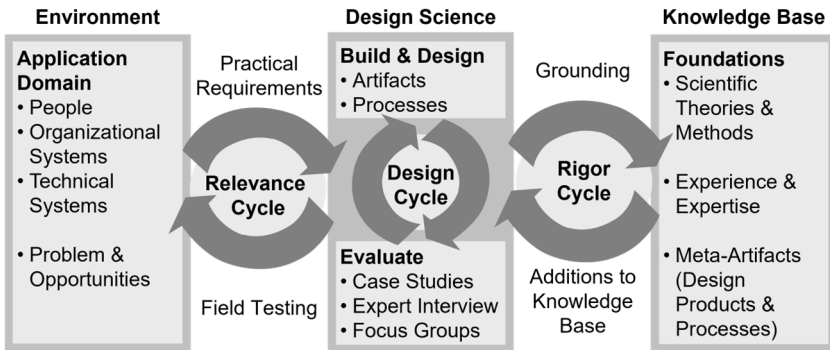


Figure 1-3: DSR approach following Hevner (2007, p. 2)

1.4.2 Consortium Research

The development of innovative artifacts for new design knowledge and novel solutions to a specific class of practical problems represent one of the core goals of DSR. There is widespread agreement in academia that an effective DSR approach stems from a combination of practical relevance and scientific rigor (Gregor & Hevner, 2013). However, a structured approach toward collaboration between researchers and practitioners has often been neglected. For example, Österle & Otto (2010, p. 283) indicate that *“research and innovation in the IS domain largely take place in the practitioner community [since] these companies usually use resources that are much larger than the resources available in academic research institutions.”* Therefore, they propose a

method where practitioners are an integral part of the research process, actively shaping the requirements and objectives over a more extended period. Following this, *consortium research* enhances the iterative DSR cycles by Peffers et al. (2007) to ensure consistent collaboration between theory and practice during artifact design. This focus on applied research objectives combined with practical evaluation improves the general applicability of innovative solutions (Österle & Otto, 2010).

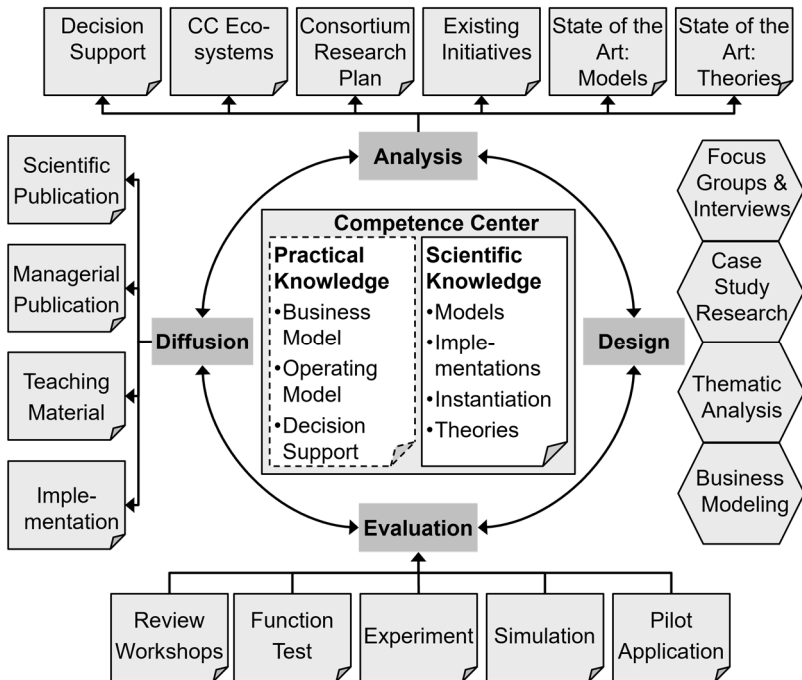


Figure 1-4: Consortium research following Österle & Otto (2010, p. 278)

The artifacts of this dissertation are developed as part of the consortium research project known as *Competence Center Ecosystems* (CC Eco-systems). This consortium is led by the Universities of Leipzig and St. Gallen and consists of several partner companies mainly situated in the financial services sector and associated areas. In several workshops, the current state of research is consistently presented, challenged, and discussed with industry representatives from over 19 firms. Focus

group meetings between workshops (i.e., working groups) are additionally conducted to ensure practical relevance and validation in detailed discussions. The instantiation of the *consortium research approach* within the CC Ecosystems is presented in Figure 1-4. The dissertation follows, for that reason, four defined iterative process steps by Österle & Otto (2010). In collaboration with the consortium and based on existing knowledge, the *analysis phase* determines research objectives and expected outcomes related to relevant industry problems and potential solutions. In the *design phase*, the artifacts are iteratively constructed. Focus groups and expert interviews, as well as prototypical instantiations, ensure the feasibility of this process. The *evaluation phase* is characterized by validating utility and applicability, considering the practical requirements for design and the principles for scientific rigor. Lastly, the *diffusion phase* disseminates the research results in presentations, demonstrations, and scientific publications. A detailed overview of the CC Ecosystem and its participants can be found in Appendix C.

1.4.3 Research Methods

Where DSR ensures relevance and rigor for the artifact design, consortium research further reinforces formal collaboration between researchers and a group of practitioners. On this basis, individual DSR cycles are conducted for each phase, using complementary methods in the dissertation research process as follows:

Literature Review: As preliminary work at the beginning of a research project, literature reviews represent “a summary of a subject field” to identify key sources and create an overview of previously published work (M. Baker, 2000, p. 219). On one side, a review of the existing knowledge base increases the relevance of the problem domain and supports the identification of a research agenda by preventing reinvestigation on a well-known topic (Rowley & Slack, 2004). On the other side, it improves rigor by providing a foundation to utilize existing knowledge for new research outcomes more effectively (Hevner et al., 2004). The dissertation follows the approach by Webster & Watson (2002) and Vom Brocke et al. (2009), who introduce a set of guidelines

for conducting a literature review and systematic search in the IS domain. Accordingly, the results from various literature reviews are used throughout this work to highlight the problem domain and identify the relevant body of knowledge in designing the artifacts.

Focus groups: The qualitative technique describes an interactive setting to gather “*data through group interaction on a topic determined by the researcher*” (Morgan, 1997, p. 6). In particular, a moderator interviews experts on their views and opinions for subsequent evaluation. Therefore, focus groups represent an appropriate approach for collecting information on a specific topic and identifying consensus within a predefined group of people (Morgan & Krueger, 1993). Following this approach for knowledge creation and evaluation in the DSR cycles, multiple focus group meetings were conducted during the CC Ecosystems between 2018 to 2021 and associated workshops with practitioners from the financial services domain. (Österle & Otto, 2010; Sonnenberg & Vom Brocke, 2012). As a result, the focus group meetings support the identification of artifacts’ requirements during analysis, the definition of design decisions during the design phase, and the assessment of applicability for practical use during evaluation.

Expert Interviews: As a frequently used qualitative method, expert interviews aim to collect and explore the knowledge of a limited number of subject matter experts. Regarding their level of proficiency, single experts are selected to conduct a structured conversation initiated by the researcher (Meuser & Nagel, 2009). The method is characterized by an efficient accumulation of information used in various ways. In this dissertation, a systematic approach is applied using semi-structured interview guidelines based on the methodological recommendations from prior research by Ayres (2008). Accordingly, practitioners familiar with the concept of tokenization and DLT-based decentralized platforms are further involved in collecting additional qualitative data.

Case study research: The research approach provides an in-depth analysis of complex social phenomena and is widely used in IS research to gain practical insights (Rowley, 2002; Yin, 2013). It supports

the collection of empirical data on novel real-world aspects, which other methods cannot achieve (e.g., experiment, laboratory) (Eisenhardt & Graebner, 2007). For studying different platform solutions associated with tokenization, the dissertation follows the case study research guidelines by Dubé & Paré (2003) that focus on research design, data collection, and data analysis. A descriptive approach based on multiple case studies is chosen to support more robust insights and establish a broader foundation for design knowledge instead of single-case research (Yin, 2013). Where Rowley (2002) suggests a number of five to ten case studies, six asset tokenization cases are investigated in this work. The approach typically combines different data collection techniques such as interviews, questionnaires, or observations.

Thematic analysis: The goal of this qualitative method lies in contextual structuring, description, and interpretation of a rich data set to identify and outline patterns in terms of so-called themes (Braun & Clarke, 2006). The applied data can be present in various forms, such as interview transcripts or articles, extending the scope of the analysis by exploring explicit and implicit meanings instead of a quantitative approach (Guest et al., 2011). Methods for thematic analysis may vary in data collection and procedures for interpretation. For the design cycles of this work, thematic analysis was applied using the methodology by Braun & Clarke (2012). Several interviews transcripts were interpreted comprising the six phases: (1) *familiarize yourself with the data*, (2) *generate initial codes*, (3) *search for themes*, (4) *review themes*, (5) *define and name themes*, and (6) *produce the report*. As a result, the approach supports the research process methodically and ensures relevance and rigor during the design of the artifacts.

Reference Modeling: A reference model is defined as an information model that can be reused to support the design of an applicable model in a practical context (Vom Brocke, 2007). Therefore, a reference model can serve as a reference point during the design process of company-specific information systems. For example, Vom Brocke (2003) introduces six principles for building reference models to ensure usability and acceptance (e.g., aggregation, specialization, or analogy). Also,

Fettke & Loos (2005) state how to construct and apply reference models in practice providing a systematic and proven approach. Besides various guidelines for orderly modeling, the mentioned theoretical foundations are additionally considered in the DSR process. These methods meet the scientific standards and reduce risks, representing the groundwork for developing the dissertation's models.

An overview of research activities for each artifact across the phases of the consortium research process is presented in Appendix B. In addition, the applied methods are also described in more detail during the artifacts design process in the respective chapters. It can be stated that the research outcomes mainly rely on primary data gathered through focus group meetings and expert interviews due to the explorative nature of the topic. The interim results were also published in conference proceedings and presented during workshops, where the discussions contributed to the further development of the framework.

1.5 Structure of the Dissertation

This dissertation aims at *a framework to enable asset tokenization business models in the financial services sector* and builds upon three primary outcomes. In combination with the DSR research paradigm, the thesis follows a structured approach and is organized across six sections shown in Figure 1-5.

The first section describes the motivation and overarching goals and introduces the research design and methods used. *Section 2* emphasizes the scope of this dissertation by presenting a conceptual foundation based on important fundamentals and related work. After highlighting the research gap and the practical relevance of the research area, three artifacts represent the main body of this thesis. Accordingly, *section 3* introduces the assessment framework to derive the business potential of asset tokenization. Next, after the conceptual model is developed and presented in *section 4*, *section 5* provides the organizational principles necessary to implement asset tokenization successfully.

Finally, *section 6* summarizes and discusses the overall findings before describing the study’s limitations and future research.

1 Introduction				
1.1 Motivation	1.2 Research Objective	1.3 Contribution & Target Audience	1.4 Research Approach	1.5 Structure of the Dissertation
2 Research Background				
2.1 Distributed Ledger Technology	2.2 Asset Tokenization	2.3 Financial Intermediation	2.4 Business Model Research	2.5 TOE Framework
2.6 Literature Review and Research Gap				
3 The Business Potential of Asset Tokenization		4 A Conceptual Model for Asset Tokenization		5 Organizational Principles for Implementation
3.1 Overview of Related Work		4.1 State of the Art		5.1 Impact of Decentralization on the Organization
3.2 Development of the Assessment Framework		4.2 Case Studies		5.2 Identification of Challenges and Solutions
3.3 Assessment Framework for Asset Tokenization		4.3 Modeling Approach		5.3 Challenges and affected Business Services
3.4 Archetypical Use Cases of Asset Tokenization		4.4 Conceptual Model Descr.		5.4 Principles to Guide Organizational Change
		4.5 Practical Application		
		4.6 Evaluation		
6 Discussion and Conclusion				
6.1 Summary of Results	6.2 Contributions to the State of the Art		6.3 Limitations and Further Research	

Figure 1-5: Structure of the dissertation

2 Research Background

The chapter introduces basic terms, theories, and fundamentals to contextualize the scope of this dissertation related to the problem domain and research outcome. The goal is to provide a conceptual foundation of previous research on interdisciplinary literature from the management and IS domains. As a consistent terminology for the tokenization of assets is still missing, an extended body of knowledge is described that partially includes grey literature and non-scientific sources. The six sections describe the fundamentals of DLT (Section 2.1), tokenization (Section 2.2), financial intermediation (Section 2.3), and theoretical foundations of business model research (Section 2.4) as well as the technology-organization-environment framework (Section 2.5) before concluding with related work on the problem domain (Section 2.6).

2.1 Distributed Ledger Technology

The section outlines the technical and business-related aspects of DLT and provides terminologies and insights into the concept of decentralized infrastructures. The sub-sections introduce basic features of the underlying technology and discuss generic application areas. In addition, different DLT-types are specified to illustrate characteristics and trade-offs from a practical perspective.

2.1.1 Introduction to Distributed Ledgers

For business transactions, databases are essential for data storage and processing within an IS. A software component in the form of a database management system (DBMS) enables the administration, control, and monitoring of the stored data and allows users to create, read, update, and delete transactions (Alt, 2021; Connolly & Begg, 2005). Typically, these databases follow a client-server model, in which several computers access a central server. Compared to centralized databases, data can also be replicated across multiple sites to increase reliability through redundancies. The concept of distributed databases also distinguishes between a homogeneous and a heterogeneous

system. Alt (2021) states that homogeneously structured distributed databases maintain identical data on multiple sites using the same operating system and distributed DBMS. In the case of heterogeneous data, the various data formats have to be translated and coordinated first to ensure consistent communication between databases. The centralized and the two distributed database systems are shown in Figure 2-1.

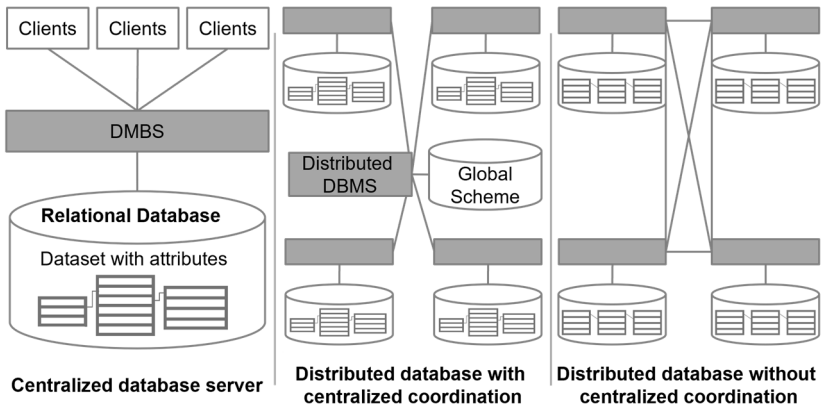


Figure 2-1: Centralized and distributed databases (Alt, 2021, p. 3)

Distributed database systems provide higher reliability, improved performance, and modular development (Özsu & Valduriez, 2020). However, to maintain a consistent copy of a particular dataset across multiple sites and keep redundant data, they still rely on centralized IS to prevent, for example, different users (i.e., computer devices) from editing the same record simultaneously (cf. concurrency control). A centralized IS is usually managed and operated by one party (e.g., external IT provider) but still poses risks to inter-organizational collaboration due to opaque business processes and information asymmetries (Kwon & Suh, 2004; Schuff & St. Louis, 2001).

On the contrary, a *decentralized IS* addresses these drawbacks by enabling firms to jointly manage, operate, and use shared IS (Beck et al., 2018; Mendling et al., 2018). Where a decentralized IS usually consists of a network of separate computing devices (cf. distributed system) that interact with each other without mediation, DLT has established itself

as the leading technology to instantiate a decentralized IS by creating multi-party systems without any central operator (Heines, Kannengießer, et al., 2021; Rauchs et al., 2018).

The emergence of DLT is strongly related to advancements in distributed systems and has been conceptually addressed almost 30 years before Bitcoin (Rauchs et al., 2018). For example, Lamport et al. (1982, p. 382) discussed the ability of a system to continue operation without interruption once its components give conflicting information in an environment that may be unreliable or malicious (cf. untrustworthy environment). He referred to the *Byzantine General's Problem* as a thought experiment and introduced the *Byzantine fault tolerance* to measure reliability in distributed systems. Accordingly, Castro & Liskov (2002) presented an algorithm that tolerates Byzantine faults to overcome malicious behavior or downtimes of its components. Also, other features of DLT have been described for some time in computer science and mathematics. For instance, Chaum (1985) introduced asymmetric cryptography for transaction systems, and Haber & Stornetta (1991) presented a scheme to digital time-stamp data securely as integral parts of the Bitcoin protocol today. This preliminary work on distributed systems can be interpreted as a breakthrough for DLT as a new database solution that ensures the management and integrity of transactions in a decentralized manner (Catalini & Gans, 2020).

From a technical perspective, DLT enables, at its very basis, an append-only distributed database for transactions with a high tamper resistance in untrustworthy environments, known as Byzantine fault tolerance (Kannengießer, Lins, Dehling, et al., 2020). Therefore, the distributed ledger relies on a network of separate computing devices, so-called *nodes*. Once a node receives new transactions, it is validated using a proof-of-ownership in digital signatures based on asymmetric key cryptography (Nakamoto, 2008). The transactional data does not directly contain the information but instead uses meta-data (cf. transaction hash). The transaction is transferred, added, and cryptographically sealed within the ledger (e.g., chain of blocks) before each node replicates and stores an (identical) copy within the network. However, all

nodes must agree on a global state to synchronize their transactions and maintain replicated data within the distributed ledger. In this case, a mechanism is needed to manage which transactions are chosen and stored by the nodes in the event of a conflict (Alt, 2021). Conflicts occur through unavailable nodes and malicious behavior of nodes, such as manipulating transactions or double-spending (cf. Byzantine fault). Instead of relying on centralized IS, the so-called *consensus algorithm* enables decentralized decision-making on a global state of the distributed ledger by managing the propagation of transactions between (equal) nodes in the network (Mainelli & Milne, 2016).

Where nodes are jointly controlled and maintained by several individuals or organizations, DLT may serve as an enabler for innovative infrastructures. In this context, DLT allows the execution of business logic formalized in software programs (cf. smart contracts, Section 2.1.3) to be effectively used in inter-organizational settings (Heines, Kannengießer, et al., 2021). In particular, its ability to replace the *centrally authorized ledger of transactions* has become the subject of many use cases (Swan, 2015). While trusted third parties establish trust by validating digital transactions between unknown participants, the associated processes and structures are often characterized by a single point of failure, increased lead times, and costly reconciliation in operations (Bertino & Sandhu, 2005). It seems logical that one of the first applications was implemented in terms of a decentralized digital currency based on the Bitcoin protocol in 2009 (Nakamoto, 2008). As trusted third parties are usually needed to exchange digital payments, Bitcoins can be sent from user to user without challenging the legitimacy of transactions through an intermediary like a bank.

Since then, a broad spectrum of solutions with different designs has emerged using the umbrella term DLT to describe the same concept (Kannengießer, Lins, Dehling, et al., 2020). BC often represents the basis for cryptocurrencies as it enables a fully public permissionless distributed ledger but is considered a specific subset of the technology (Rauchs et al., 2018). Although the terms DLT and BC are often used as synonyms in discussions, a distributed ledger is not necessarily

dependent on employing a BC. Previous applications show that various DLT solutions can store an increasingly versatile amount of transaction records (Collomb & Sok, 2016). Accordingly, the dissertation primarily focuses on DLT as the appropriate level of abstraction.

2.1.2 Cryptocurrencies

Successfully implemented as a *peer-to-peer electronic cash system* based on Satoshi Nakamoto's² whitepaper in 2009, Bitcoin and other digital currencies represent the first practical application area of DLT (Nakamoto, 2008). Although the efforts to introduce a digital currency started with personal computers and the internet in the late 1980s, these projects did not succeed (Burgess, 2016). One prerequisite of transferring electronic money in bits and bytes is authenticity and security. Whereas *“real money inheres sophisticated security marks and cannot be physically in two places at once, digital data can be easily copied or intercepted”* (Omran et al., 2017, p. 17). Electronic bank transfers address these counterfeiting and double-spending issues by monitoring and controlling transactions through highly restricted centralized systems (e.g., SWIFT payment network). Many early digital currencies were based on such structures, as they strongly relied on a central clearing mechanism. Not able to compete with state-of-the-art mainframes, a single point of attack of one legitimate server led to their failure in each case (Antonopoulos, 2014). Besides new developments in cryptography, alternative concepts were appreciated. Bitcoin's underlying BC protocol prevented such attacks by combining know-how in database technology, encryption, and distributed systems leading to the first functional implementation of the distributed ledger concept. Based on Antonopoulos & Wood (2018), the main pillars of the BC are summarized below, complementing key components relating to DLT:

Peer-to-peer architecture: The topology establishes the basic network structure of nodes and defines access, rights, and tasks between peers to be equally privileged and capable. Bitcoins are, for example,

² The inventor of Bitcoin used the pseudonym Satoshi Nakamoto in a whitepaper to describe the implementation of a decentralised digital cash system known as Bitcoin Core (cf. Nakamoto, 2008).

exchanged by updating the distributed ledger directly across an open network of equiptent nodes that validate and store the transactions.

Cryptography: Public-private key pairs, digital signatures, and cryptographic hash functions are used to ensure access to pseudonymous Bitcoin accounts (i.e., wallets), authentication of participants, non-repudiation of transmissions, and integrity of transaction messages.

Data structure: Instead of including all transactions in one database, the ledger consists of consecutive data blocks individually secured and cryptographically sealed. The blocks are linked together, referring to previous data within a chain. New blocks are added once a group of incoming transactions is validated and updated in the system.

Consensus mechanism: An algorithm allows nodes to agree on a global state, synchronize their transactions, and maintain data consistency within the distributed ledger. Besides Bitcoin's *Nakamoto consensus*, known as *proof-of-work* (PoW), there are various alternative mechanisms such as proof-of-stake (PoS), proof-of history, and many more.

BC protocols often form the basis for digital currencies (cf. cryptocurrencies or crypto coins) and represent a subset of DLT that typically operates in a public permissioned environment, which is pseudonymously³ accessible by any participant without authorization. Unlike paper money, cryptocurrencies are generally not issued by a central bank and require so-called *validators* to maintain the system independently. Therefore, an incentive mechanism (e.g., mining, staking) is implemented to reward network participants for activities involved in the consensus mechanism. The PoW algorithm requires computational resources to let participants solve a complex mathematical problem and add transactions to the BC. The algorithm creates a race between each participant every time a new block has been finished, rewarding only those that solve the puzzle first and comply with the system's rules. If enough computational power is devoted and the consistency criteria are

³ For a person holding the cryptographic keys to access an account, the BC is pseudonymous since any action can only be traced back to the specific address of the public key but not to the holder itself.

met, the validator (i.e., miner) is compensated with 6.25 Bitcoins as of November 2021 (<https://bitcoin.org>). Regarding the PoS mechanism, validators support the network's operations by locking cryptocurrencies and being rewarded for contributing to the consensus proportionally to the number of coins staked (Alsindi & Lotti, 2021, p. 5).

The concept encouraged the open source community to implement alternative cryptocurrencies (i.e., altcoins), but Bitcoin is still considered one of the most important and widely used. Accordingly, several sub-types of cryptoassets emerged, such as stable coins pegged to a legal currency or a commodity, such as gold, to withstand volatility. Although cryptocurrencies have no official legal tender status, they inspired the idea of a central bank digital currency (CBDC) to be backed and issued by governments and central banks (Han et al., 2019). As a result, three primary uses of cryptocurrencies have been identified: *investing purposes*, *means of exchange*, and *store of value* (Freni et al., 2020). It is widely discussed if cryptocurrencies should be considered currencies as they fulfill several requirements to be recognized as one (e.g., value preservation, unit of account, and means of payment). The discussions increased the pressure for new legal frameworks, where legal arrangements significantly vary internationally (Schlatt et al., 2016). With the basic understanding of this application area, cryptocurrencies are covered in this dissertation as an individual asset class to be further defined in the context of asset tokenization in Section 2.2.2.

2.1.3 Smart Contracts

By following the idea of converting contractual agreements into computer code, Szabo (1997) introduced the concept of *smart contracts* as a set of promises that can be trustless and self-enforcing to improve efficiency and remove ambiguity from contractual relationships. Typically, a legally binding contract is a paper-based document that defines mutual obligations between two or more parties and relies on a trusted intermediary within a legal framework to enforce these rights (Sayre, 1927). Therefore, several technical requirements must be met to execute agreements digitally between unknown parties reliably and

effectively (e.g., replicated asset register, fault-tolerant replication). Due to its technical features, the first early version of smart contracts was encoded in the Bitcoin protocol using a script that formalized the coin's transfer (Atzei et al., 2018). As a result, DLT today provides a suitable infrastructure to implement agreements digitally, with new frameworks such as Ethereum, enabling more advanced smart contract functionalities (e.g., Turing-complete smart contracts) (Buterin, 2018).

Based on this, smart contracts are defined as software programs that deploy business logic formalized in computer code for reliable enforcement of business agreements between participants, such as individuals, firms, or machines (Kannengiesser et al., 2021). Once certain conditions are met, they execute the predefined business logic (Wright & Filippi, 2015). An analogy is drawn to a simple *IF-statement* that returns a boolean value defined as *IF (Something is true, then enable something, otherwise enable something else)*. The smart contract uses external data as input, which is then mapped against a specific ruleset of the agreement to execute a defined logic (Schlatt et al., 2016). For Ethereum, the corresponding scripts are stored in a particular wallet address. Once an external event occurs, a transaction is sent to this address to execute the business logic accordingly (Buterin, 2018).

Smart contracts are an essential component of DLT because they significantly increase the range of application areas considerably. According to Swan (2015), they automate interaction by allowing agreements to be executed, enforced, and verified autonomously based on the security and efficiency of algorithms. Whether it is about e-commerce, autonomous machine-to-machine communication, or automated asset fund allocation, the potentials have been widely discussed (Schlatt et al., 2016). For example, a car holder uses a digital security system with smart locks and an ownership token without physical keys. For theft prevention, the vehicle is inoperable unless the protocol confirms the token transaction to its rightful owner. Once the car is used to secure a credit loan, an additional protocol is designed and implemented. The ownership token is sent to a wallet address representing the security. The car holder loan repayments are linked to the wallet address setting

up an agreement based on a smart contract. If the owner misses the installments, the smart contract initiates the protocol and transfers the ownership token immediately to the bank and so on. Once the loan is paid, the lien is automatically removed from the wallet. In this case, a smart contract constitutes an automated, cheaper, and more effective alternative to a conventional liquidation (Swan, 2015).

Especially within the BC community, smart contracts are perceived as enablers for so-called decentralized applications (DApps). They are successfully applied in decentralized finance (DeFi) cases to offer automated financial services (e.g., lending, crypto exchange) in a more transparent and decentralized manner (Schär, 2021). However, contracts often involve a degree of ambiguity that makes it challenging to implement and automate execution in software code. Moreover, there is still controversy about whether and how smart contracts can constitute a valid, legally binding agreement. If contractual terms, legal frameworks, and technological difficulties are successfully solved, the widespread adoption of smart contracts will significantly impact both the economy and society today (Hughes et al., 2019).

2.1.4 Types of Distributed Ledgers

Since the implementation of Bitcoin, an increasing number of DLT-based use cases have been developed in various application areas, such as logistics and finance. DLT is applied as an infrastructure, where its underlying technology components continuously evolve (Casino et al., 2019). Besides using blocks to store transactions for many cryptocurrency applications, new DLT concepts have been established that are characterized by higher availability or transaction throughput. Therefore certain application areas utilize specific DLT designs (e.g., Ethereum, R3 Corda) that represent a distinct DLT concept (e.g., BC, PoW) with unique characteristics and individual properties (Kannengiesser, Lins, Dehling, et al., 2020). Different classification approaches and typologies are appreciated, where DLT can be generally classified across two access dimensions (Heines & Guerpinar, 2021). As shown in Table 2-1, one dimension focuses on access to transactions by

network participants (i.e., nodes) that defines read permissions in a public or private setting. A public DLT implies no restrictions on reading and proposing new transactions. On the contrary, a private DLT requires explicit permission by a group of predefined entities to read and submit transactions. Accordingly, permissioned and permissionless refers to the scope of writing data into the distributed ledger, more specifically to validate transactions and participate in consensus. Permissionless DLTs allow all nodes to validate transactions and append data to the distributed ledger. In a permissioned setting, only predefined nodes can participate in the consensus mechanism (Peters & Panayi, 2016).

		Access to Transaction Validation	
		Permissioned	Permissionless
Access to Transactions	Public	• All nodes can read and submit transactions • Only authorized nodes can validate transactions	• All nodes can read, submit, and validate transactions
	Private	• Only authorized nodes can read, submit, and validate transactions	Not Applicable

Table 2-1: DLT typology (Beck et al., 2018, p. 8)

Depending on the participants involved, the different DLT-types offer multiple possibilities to define various layers of accessibility. Commonly referred to as enterprise DLT or BC, private permissioned DLTs are often used by consortia of numerous organizations to gain shared control over transactions’ reading and writing processes. However, if a ledger is entirely closed for its participants, many vital characteristics may be undermined to create an open and unrestricted network.

A DLT design such as Ethereum can be further specified based on the features of their DLT concept. Accordingly, Table 2-2 compares the most notable DLT designs such as Bitcoin, Ethereum, Hyperledger, and Corda with a brief summary in Appendix A.1. The identified features of the DLT types build upon previous work (cf. Plazibat, 2019; Sandner,

2020; Saraf & Sabadra, 2018). Some features (i.e., network access & validation, consensus mechanism, programmable logic, data broadcast) serve as decisive building blocks for DLT-architectures and are also specified as part of the conceptual model for asset tokenization in Section 4.4.5. It can be shown that different trade-offs and design options between specific DLTs exist. While the choice for a DLT-design may lead to implications for the entire IS, the use case requirements should always provide the basis for decision making.

Features	Bitcoin	Ethereum	Hyperledger Fabric	R3 Corda
Description	Peer-to-Peer electronic cash system	Open Source BC-based platform	DLT-based platform with a modular architecture	DLT-based platform
Purpose	Payments and store of value	Development of DApps	Use Cases for industry consortia	Use Cases for the financial industry
Governance	Bitcoin Core Developers	Ethereum Developers	Linux Foundation	R3 Consortium
Network Access & Validation	Permissionless, Public	Permissionless, Public or Private (Enterprise Ethereum)	Permissioned, Private	Permissioned, Private
Consensus Mechanism	Mining-based PoW	Mining-based PoW moving to PoS (Ethereum 2.0)	Selection of mechanisms to be used in closed environments	Specific scope of consensus in closed environments (i.e., notary nodes)
Programmable logic	Scripted transaction logic (e.g., UTXO model)	Smart contract code (Solidity)	Smart contract in chaincode (e.g., Go, Java)	Smart contract code (e.g., Java); Smart legal contract (legal prose)
Token Type	Bitcoin as native token	Ether as native token; Token creation via token contract (e.g., ERC-20)	Native tokens are not required; Token creation via chaincode	Native tokens are not required; Token creation via token SDK
Data Broadcast	Globally replicated across ledgers	Globally replicated across ledgers	Locally replicated on transaction level	Locally replicated on transaction level

Table 2-2: Comparison of DLT designs and their features

2.2 Asset Tokenization

This section describes the fundamentals of asset tokenization, including its basic concept and role in innovative business models. It introduces definitions relevant to the dissertation and outlines the opportunities of a token economy for the financial services sector.

2.2.1 Concept of Tokenization

A settlement of digital transactions often requires trusted third parties to authenticate a transfer of ownership between unknown participants (e.g., SWIFT payment network). Therefore, the operations that involve intermediaries are typically characterized by increased costs, time-consuming processes, and exposure to a single point of failure. To overcome such challenges, DLT can ensure the management and integrity of transactions without relying on mediation by trusted third parties (Kannengießer, Lins, Dehling, et al., 2020). Cryptocurrencies are the most prominent example, where the technology enables a peer-to-peer transfer from one user to another without questioning the transaction's legitimacy through a trusted financial intermediary (Nakamoto, 2008).

The emergence of new DLT frameworks and smart contracts (e.g., Ethereum's token contracts) extended the functionality of the technology, which led to a facilitated form of crowdfunding in the past. ICOs introduced BC-based *tokens* to be issued and sold in exchange for cryptocurrencies to investors seeking public investments for their company in return (Roth et al., 2019). A token is a well-known concept in economics to represent something else, typically used in local and closed environments such as loyalty programs, casino chips, vouchers, laundry credits, or access permission, to name a few (L. Oliveira et al., 2018). As a result, tokens further developed into an instrument to digitize anything that may represent an asset, utility, or ownership due to their usefulness in their respective context. Applied to DLT-based platforms, Pilkington (2015) defines tokens as ideal value containers for divisibility, ease of use, and facilitating trade. One advancement that has gained growing attention since early 2018 and emerged from the original concept is the so-called *tokenization of assets*. In current

research and practice, the term and its environment are defined in various, sometimes contradictory ways. Babich & Hillary (2020) discuss tokenization in operations management to create and assign ownership rights facilitating the exchange and trade of products between multiple participants. Zhou et al. (2019) mention this concept to convert medical data to secure IT systems processing. Although assets are initially defined as literally anything that has value to a particular stakeholder (Greer, 1997), the terms *digital assets* and *cryptoassets* are almost exclusively used to describe a financial asset class (OECD, 2020).

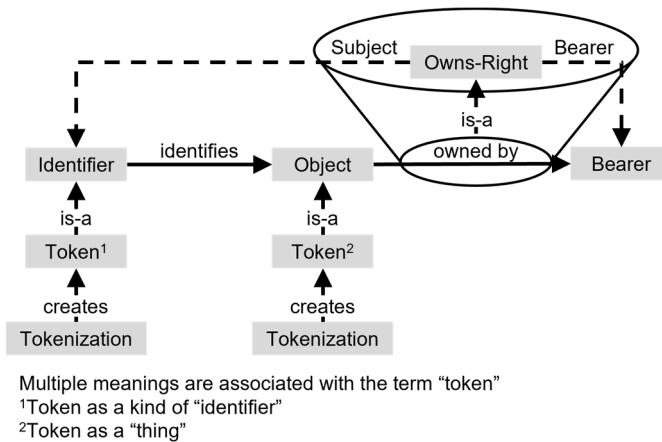


Figure 2-2: Intensional and extensional definitions of tokenization

According to multiple meanings associated with this phenomenon, an extensional and intensional definition of tokenization is introduced (Figure 2-2). Dependent on the features of DLT, tokenization can be extensionally described as the process of creating a token on a distributed ledger in terms of a singular identifier that enables a unique and persistent reference (i.e., token as a kind of identifier). As everything can be represented by creating such reference, a token can also be distinguished by serving as a bearer instrument (i.e., token as a thing). Following this intensional definition, tokenization creates a real-world instantiation once an underlying legal relationship is established and a specific bearer is assigned to that right (e.g., ownership rights are technically embedded into a smart contract). By adding individual properties

and functions of any asset into a token, it can be designed to be unique, tradeable, liquid, secure, scarce, and much more (Meijer, 2020). From a technical perspective, tokenized assets rely on a specific data structure and additional logic mainly implemented on integrated DLT-based platforms to achieve the desired functionality. Roth et al. (2019) differentiate between UTXO-based, layer-based, and smart contract-based token standards. Common standards refer to Ethereum's *ERC-20* and *ERC-721* token contracts (Appendix A.2). Dependent on the specific use case, each token standard comes with individual trade-offs.

Another common difference must be drawn between tokenized assets that exist *off-chain* and *native on-chain* tokens. For instance, the tokenization of a *physical asset* that exists *off-chain* relies on an underlying object to act as a store of value. An example would be a token backed by a fiat currency or a digital twin representing a real car. Such systems differ from native record-keeping, in which a *native* token is built *on-chain* and is only existent within the system. In that regard, Bitcoin and other cryptocurrencies are *native* tokens that derive their value in and of themselves (OECD, 2020). In contrast to the tradeability with other tokens of the same type, one widespread manifestation is a so-called *non-fungible token* (NFT). Often used to create digital scarcity, they are unique by individual specification and represent anything from a piece of land to collectibles (e.g., art, classic cars) (Roth et al., 2019).

With regards to the novelty of this topic, tokenization is defined in this dissertation as the process of creating a unique singular identifier on a distributed ledger in the form of a token that may digitally represent anything from valuable objects (e.g., artwork) or contractual rights (e.g., ownership right) (Distefano et al., 2020; Harwood-Jones, 2019). With the emergence of new initiatives, it is not unlikely that most assets will be digitized based on this innovation in the long run (Harwood-Jones, 2019). Specifically, as part of a token economy, tokenization has the potential to transform our economic system by enabling new services and business models that lead to greater accessibility and democracy (Sunyaev et al., 2021). However, it will be crucial to establish a shared understanding and provide a sound basis for strategic decision-making.

2.2.2 Token-based Business Models

One of the main features of DLT refers to its transfer capability providing proof of ownership through cryptography and preventing malicious fraud attempts by replicating data across thousands of nodes. Its decentralized record-keeping allows its users to check and verify transactions without the need to question their legitimacy through a third party. Following Tapscott & Euchner (2019), trustless value exchange is further the basis for a so-called *internet of value* to complement centralized IS and initiate a new era for digital assets. As shown in Figure 2-3, DLT extends the concept by providing a new form of cryptoassets, synonymously referred to as the group of cryptocurrencies, coins, or tokens.

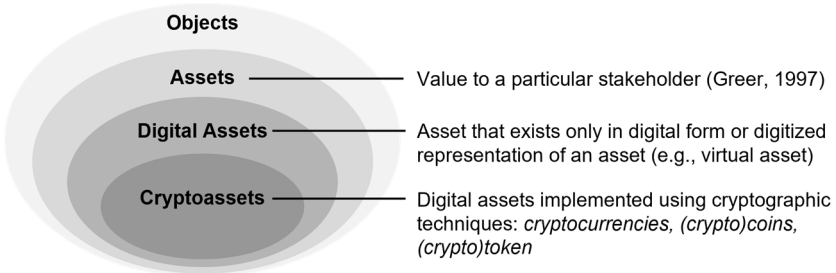


Figure 2-3: Cryptoassets and associated concepts

From a functional perspective, cryptoassets are further divided into cryptocurrencies and tokens (Xu et al., 2019, p. 17). While both may digitally represent a valuable object (i.e., currency) in their respective context, cryptocurrencies are typically *native* to a public permissionless DLT and provide incentives for nodes to validate transactions and operate the system (e.g., Bitcoin mining). However, they might share the same infrastructure building upon each other (e.g., Ether and ERC-20 token). Based on this knowledge, the study neglects the role of cryptocurrencies to focus on tokens as digital representations of a *thing*.

The economic and social activities facilitated by a next-generation internet using tokens (i.e., Web3) are commonly referred to as a token economy. As companies commercialize innovation and new technologies based on their business models, it is assumed that asset

tokenization enables various opportunities for new market outcomes in this field. Figure 2-4 presents an overview of strategic business areas, where a distinction can be made between the *optimization of existing* and the *introduction of new business models*. In most cases, asset tokenization is not technically but rather economically motivated. For example, Heines & Guerpinar (2021, p. 96) illustrate application areas that “*aim to reduce transaction cost associated with automated execution and contracting.*” Sunyaev et al. (2021, p. 471) further add the potential of tokenization to “*replace the role of trusted third parties and thus avoid the cost of intermediaries.*” As a result, the improvement of *existing business models* is further divided into *process optimization* without removing trusted intermediaries and *structural optimization* combining processual and structural benefits of tokenization through disintermediation. The introduction of new business models can also be separated into two areas. On the one hand, *reintermediation & new market entry* offer familiar services and products that were not economically viable (e.g., micropayments) before. On the other, *decentralized platform businesses* implement innovative services through DLT-based platforms that were previously not technically feasible (e.g., peer-to-peer cash system, decentralized autonomous organization (DAO)).

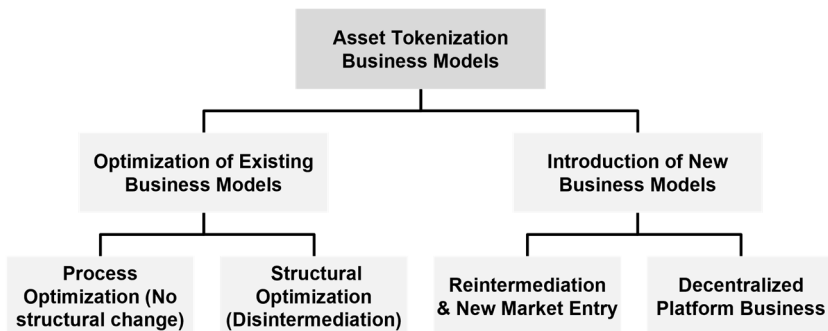


Figure 2-4: Scope of asset tokenization business models

2.3 Financial Intermediation

The section provides a conceptual background on the role of financial intermediaries and the essential elements of a financial system. It sets

the starting point to describe the implications of asset tokenization business models in the financial services sector and outlines the perspective on asset transfer and ownership in the context of the dissertation.

2.3.1 Functions of Financial Intermediaries

Intermediation represents a financial system's core activity to allocate economic resources efficiently (Lin, 2015). Institutions or individuals, who facilitate financial transactions for an efficient allocation, are known as financial intermediaries, such as banks, brokers, or exchanges (Bernet, 2003). According to Merton (1995), financial intermediation can be described by taking an *institutional* or *functional* viewpoint. Following an *institutional perspective*, existing institutional structures typically serve as the starting point to investigate how public policy and other measures improve or sustain the overall financial system's stability. The *functional perspective* address functions as a matter of interest to explain how intermediation services can be performed more efficiently and profitably. Figure 2-5 illustrates the functional perspective, where financial intermediaries serve as a middleman to (re)allocate financial resources based on a so-called allocation function to minimize transaction costs or risks for all market participants (Bernet, 2003). For achieving this objective, the core functions are further separated into five areas to be performed as follows (Bernet, 2003; Merton, 1995):

Transfer function: Financial intermediaries have to ensure cost-effective and efficient payment transactions to exchange goods and services in an economy.

Transformation function: The intermediary allocates the demand for capital (e.g., investments) and its supply (e.g., pooling of deposits). The function may also take a temporal dimension into account (i.e., term & life cycle transformation) to meet the market's needs individually.

Risk allocation function: The financial intermediary provides a mechanism to manage uncertainty and support risk transfer according to diversification, hedging, and insurance.

Logistics and service function: Financial intermediaries create mechanisms and establish instruments to meet finance-related market needs.

Information function: According to asymmetric information and lack of incentives, intermediaries provide information on the risks and prices of financial assets, financial transactions, and related processes.

In addition, Bernet (2003) introduces the role of a *financial service provider*, who offers a broad range of products and services associated with intermediation (e.g., banks, insurance companies, or investment funds). On the opposite lies the *demand for financial services* by commercial clients or institutional customers. Accordingly, *financial markets* meet supply and demand to trade products or offer services at low transaction costs (Valdez & Molyneux, 2015). The related trade activities are further supported by a clearing and settlement mechanism provided by a *settlement system* and completed through a *payment system* to ensure secure and efficient delivery versus payment processes. The *information and communication systems* further ensure the exchange of necessary information between market participants. Finally, the financial system's viability, integrity, and stability for both providers and consumers are established through a *supervisory system* based on regulatory authorities and an appropriate regulatory framework. The different elements may vary based on jurisdictions, market characteristics, or the degree of interaction (Bernet, 2003; Merton, 1995).

"Where external aspects change how core functions are performed, the institutional structures must also change (Bernet 2003, p. 7)". Accordingly, the functional perspective represents an appropriate framing to investigate asset tokenization business models in the financial services sector. This dissertation assumes that DLT might fundamentally impact the core functions of financial intermediation (e.g., transfer function), where asset tokenization enables intermediaries to deliver existing services and new products across markets more efficiently. Thus, digitalization is challenging the status quo, while it is expected that financial intermediation is by no means becoming obsolete shortly (e.g., risk

allocation, regulation). The dissertation's artifacts address this scope and accordingly contribute to this understanding.

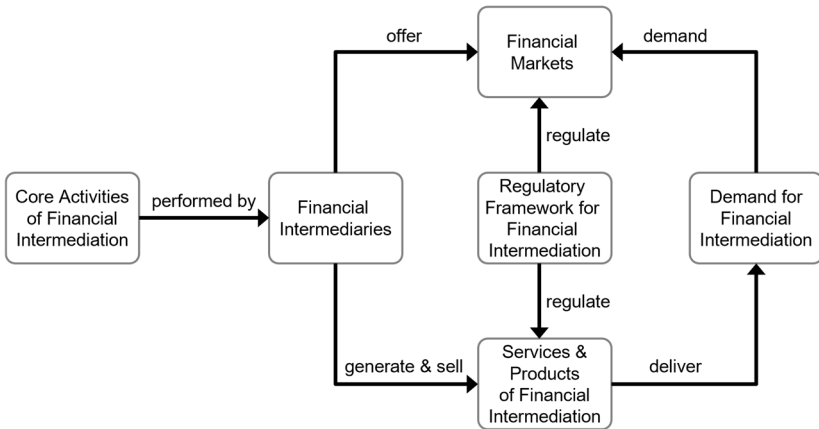


Figure 2-5: Functional context of financial intermediation (Bernet, 2003, p. 18)

2.3.2 Transfer of Assets

With a focus on the transfer function of financial intermediaries, it is appreciated to take a closer look at the management of asset ownership in traditional financial markets. It is assumed that DTL significantly differs from conventional systems, with implications for both processes and structures (Heines & Guerpinar, 2021).

A simplified clearing and settlement scenario of securities is introduced in Figure 2-6, which illustrates the essential participants and steps. Following the example of Guadamillas & Keppler (2001), several financial intermediaries, institutions, and regulatory authorities are directly and indirectly involved. After receiving the buying and selling orders for securities, the broker places them on the exchange. Once the order is executed, a confirmation is sent to the custodian banks and is forwarded for post-trade processing to the clearing & settlement system. At this stage, a clearinghouse serves as a central counterparty (CCP) to ensure the exchange between the buy and sell sides. The CCP guarantees payment and asset delivery obligations and faces the probability that transactions from either side might fail (i.e., counterparty risk).

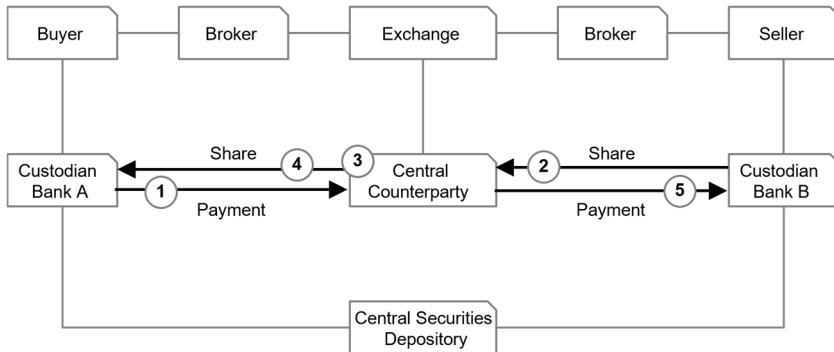


Figure 2-6: Clearing & settlement process (Guadamillas & Keppler, 2001, p. 6)

On that basis, different settlement schemes exist to prevent loss (e.g., free delivery, delivery versus payment (DVP)). It is often required that the buying party completes the payment transaction (1) before or at the time of delivery of the relevant shares. Once the CCP receives the payments and the selling party delivers (2), the CCP can approve that the obligations have been met (3). Then, the pending delivery to the buyer (4) and the payment transaction for the sell-side (5) are initiated. Next, the central securities depository (CSD) triggers the transfer of ownership for the assets held in custody by the responsible bank. Finally, the information about the successful trade is forwarded to the customers.

2.4 Business Model Research

The section describes relevant aspects of business model research to provide a foundation for a framework that enables asset tokenization business models in the financial services sector. In particular, the sub-chapters describe the generic concept, business model components, and the process of business model innovation to introduce a conceptualization for the artifacts and set the groundwork for further discussion.

2.4.1 Concept and Definition

According to Osterwalder et al. (2005), the emergence of the term business model can be traced back to the 1950s, occasionally being used in a very vague context and within diverse settings. With the rise of the

new economy in the 1990s, the term gained prominence to be associated with commercial activities and information technology. The internet has enabled companies to develop new ways of generating value entirely on existing or emergent technology. In this context, business models offer the opportunity to analyze, develop, or compare different approaches toward an organization's value creation (Wirtz et al., 2016). As a management tool for practice, the concept has been widely applied and gained increasing attention to maintain and enhance competitive advantage (Johnson et al., 2008). This popularity also led to a growing significance in scientific discourse, where business models are a known subject of study for the academic community beyond management science today (Zott et al., 2011). However, a common understanding of the concept has not yet been established (Alt & Zimmermann, 2001).

According to the various research fields, the term may refer to a *business idea*, *business concept*, or just an *economic model*. Following Wirtz et al. (2016), the current state of business model research focuses on three research streams: (1) *concepts and terminology*, (2) *structure*, and (3) *management process* of business models. The first stream deals with a general framing, conceptualization, and definition of the term. By applying different theoretical lenses, such as the resource-based view, several authors provide concepts and distinguish them from the current ones (Teece, 2018; Zott et al., 2011). The second stream is based on a component-oriented view and investigates how business models can be represented and categorized. According to Stähler (2002), the concept is built around three components: *value proposition*, *value architecture*, and *profit equation*. In addition, Osterwalder (2005, p. 17) introduces a business model ontology consisting of “a set of elements and their relationships and allows expressing a companies logic of earning money.” Within this context, the existing literature further refers to business models as a *description* (Weill & Vitale, 2001), *representation* (Amit & Zott, 2001), or *architecture* (Timmers, 1998) of value creation regarding various components such as *actors*, *core logistics*, and *processes*. The third stream focuses on a dynamic view and primarily addresses the conceptual nature of the business model for changing existing and developing new ones

(Hedman & Kalling, 2003; Morris et al., 2005). Commonly referring to *business model design*, *business modeling*, or *business model innovation*, the goal is to create new value for customers or deliver value in a novel way based on model-oriented and method-driven approaches. On that basis, several methodologies have been established, ranging from practical business model blueprints (Gassmann et al., 2017) to high-level conceptualizations (Frankenberger et al., 2013) and systematic engineering-oriented approaches (Österle & Winter, 2003).

While the business model is primarily seen as a “*mechanism that connects a firm’s technology to customer needs and to other firm resources*” (Zott et al., 2011, p. 1034), the business model concept provides an appropriate framing to introduce asset tokenization in the financial services sector. According to its conceptual nature, this work follows a component-oriented view and includes selected business model components as a basis for the frame of reference with its three respective artifacts (e.g., value proposition, value architecture of asset tokenization). The construction and modification process is also partially covered as part of business model innovation to support the ideation, design, and implementation of asset tokenization business models. As a result, the overall framework extends and complements existing approaches instead of representing a methodology on its own.

2.4.2 Business Model Components

In addition to the terminology of business models, a closer look at the different components in literature is taken to develop a clearer understanding of the overall concept (Wirtz et al., 2016). Many publications refer to a component-oriented perspective, where “*a business model can be conceptualized as a system that is made up of components, linkages between the components, and dynamics*” (Afuah & Tucci, 2001, p. 4). However, a common understanding of the various aspects significantly varies between authors and is further dependent on the purpose of such conceptualizations. Bucherer (2010) introduces three categories: *descriptive*, *explanatory*, and *decision model*. A descriptive business model captures and visualizes a business's current, past, or

future state to support internal and external communication (Osterwalder et al., 2005). An explanatory model is applied to investigate, evaluate, and identify the most relevant elements of a company, where decision models represent a basis to support planning, change, and implementation proactively (Morris et al., 2006).

Several authors refer to a meta-model by following general modeling principles and pointing out three main components (Osterwalder et al., 2005; Richardson, 2005; Stähler, 2002). Firstly, the *value proposition* describes the products and services offered to specific market segments. Secondly, *value creation and delivery* present how products and services are created and brought to the customers. Thirdly, *value capture* illustrates profitability by specifying the income streams, costs, and capital employed. A more detailed framework to characterize business models is presented by Morris et al. (2005). It comprises six components. Besides economic factors, it extends the *firm's value offering by market aspects* and more specified elements such as *internal capabilities*, *competitive strategy*, and *growth factors*. In particular, *actors* and their *interactions* are typically an essential component of so-called *value networks* in the literature. Actors, such as suppliers, business partners, or providers, collaborate to generate value based on core competencies (Al-Debei et al., 2008; Voelpel et al., 2004).

Another focus lies in *value architectures* often described in various degrees of abstraction to address a general structure and functional topology of value creation (Wirtz et al., 2016). In particular, the sub-components describe relevant aspects to deliver the value proposition to the client representing *value streams*, *key processes*, or even *technical architectures* (Bouwman et al., 2005; Mahadevan, 2000). The sub-components provide an abstract visualization of the organization's core business logic, but a more granular blueprint to align strategy and tactics in the form of business architectures may be required (Beckett & Dalrymple, 2019). However, many frameworks and models have been developed in recent years (Gassmann et al., 2017; Osterwalder & Pigneur, 2010). Based on the ontology of Osterwalder (2004), the *business model canvas* focuses on the value proposition for the customer

with additional eight building blocks. Other approaches, such as *business engineering*, extend the possibilities of an abstract representation by covering all organizational levels of an enterprise, including *strategy*, *processes*, and *information systems* (Österle & Winter, 2003).

Various approaches with a broad set of business model components exist. Besides heterogeneous aspects in the literature, it can be stated that the applicability of such models strongly relies on their degree of abstraction. This dissertation aims to provide a reference framework to support business model innovation in the financial services sector, with asset tokenization explicitly affecting the value proposition and architectural components of a company's business model. However, a comprehensive approach for gaining insights into business potentials, value creation, and organizational change of tokenization is not available yet.

2.4.3 Business Model Innovation

Business models provide a blueprint to commercialize technological innovation, but they must be managed and developed over time (Morris et al., 2005). Accordingly, the process of construction and modification refers commonly to business model innovation (Geissdoerfer et al., 2017). By consistently changing one or multiple components in the business model, value can be created and captured in novel ways (Amit & Zott, 2001; Teece, 2010). Depending on the industry, a need for business model innovation is typically triggered by external factors (e.g., new competitors, shifting markets, regulatory change, disruptive technologies) leading to new products, services, and processes (Bucherer, 2010; Comes & Berniker, 2008). Several research streams on business model innovation investigate, for example, the relationships between innovation and firm performance (Demil & Lecocq, 2010) or identify opportunities and barriers toward a successful business model change (Chesbrough, 2010). However, existing research also provides approaches to support practitioners in transforming existing and establishing new business models by following a processual perspective.

Wirtz et al. (2016) highlight the business model management process as an important area of research to support decision-makers. Accordingly, the proposed business model innovation process refers to six phases. Where *idea generation* allows developing the first set of ideas strategically, the subsequent *feasibility analysis* evaluates implications for the developed concept. *Prototyping* creates a more precise implementation scenario for a group of ideas before the developed prototypes are reviewed in the *decision-making* stage. The *implementation* considers further aspects, such as detailed planning and budgeting. Finally, the process concludes with *monitoring & controlling* to reflect on the implemented business model and the realized changes to satisfy the customers' needs (Wirtz, 2020). In addition to the nine building blocks of the business model canvas, Osterwalder & Pigneur (2010) present five phases for initiating the design process. The step *mobilise* describes the overall setup of the project by defining the objectives, testing the initial idea, and setting up the team. *Understanding* refers to basic research and collection of the required information. While the *design* step consists of brainstorming and prototyping, *implementation* relates to the realization and communication of the concept in the field. Lastly, the business model is adapted and modified during the *manage* step according to the market needs.

Based on innovation management literature and empirical data, the *4I-framework* by Frankenberger et al. (2013) provides a comprehensive approach across four subsequent steps that highlight managerial challenges faced during the process. As shown in Figure 2-7, the generic phases start with the *initiation*. The stage addresses critical challenges in understanding the stakeholder needs (e.g., customers, suppliers, competitors) and overcoming uncertainty by identifying the driver for change (e.g., competitors, technology, regulation) and analyzing the broader business ecosystem. The *ideation* phase deals with idea generation turning concepts into concrete outcomes. Out-of-the-box thinking, methods, and tools are required to facilitate the identification of new opportunities. Next, the identified ideas must be converted into a viable business model during the *integration*. In addition to partner management, the alignment between strategic and operational goals is the

biggest challenge in this phase. In the *implementation* phase, it is required to overcome internal resistance and manage the chosen implementation approach. Accordingly, expectation management, best practices, and pilot cases support the mitigation of risks.

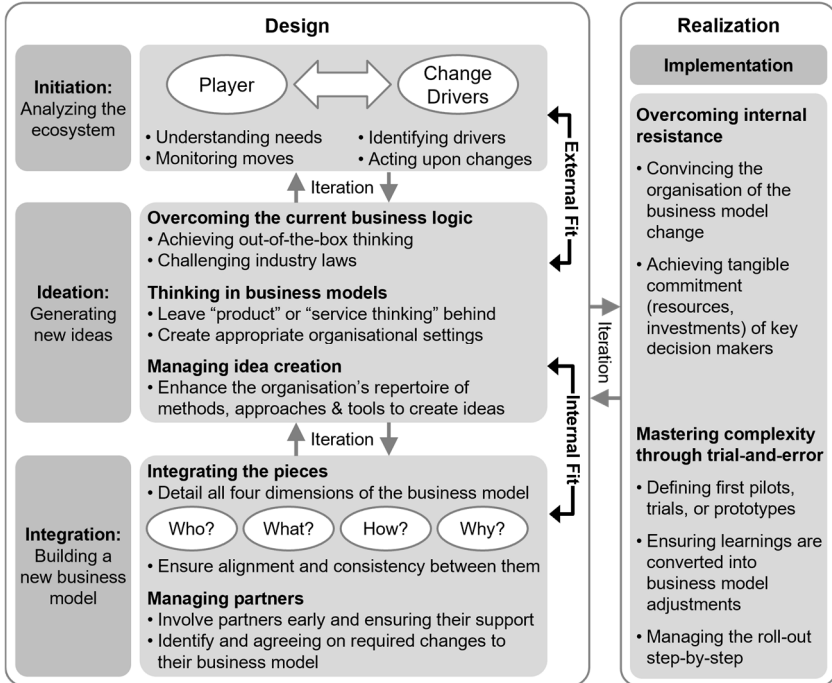


Figure 2-7: Phases of the business model innovation process and their key challenges (Frankenberger et al., 2013, p. 264)

The contributions show general agreement among the main phases of the business model innovation process but differ on more detailed sub-phases (Bucherer, 2010; Geissdoerfer et al., 2017). While the dissertation’s framework supports business model innovation in the financial services sector, its three artifacts address several aspects of this research area to develop a holistic foundation for ideation, design, and implementation. Accordingly, business model research represents an appropriate groundwork for both practice and academia to enable asset tokenization and accelerate the widespread adoption of this disruptive innovation.

2.5 Technology-Organization-Environment

Framework

The following section introduces the technology-organization-environment framework (TOE) to conceptualize the adoption of technological innovation in organizations. Influenced by a technical, organizational, and environmental context, it provides an appropriate structure to describe the implementation of asset tokenization in the financial services sector. Accordingly, the TOE framework with its associated elements is presented first before the section closes with an overview of its use in existing research and its relevance for this work.

2.5.1 The Framework and its Elements

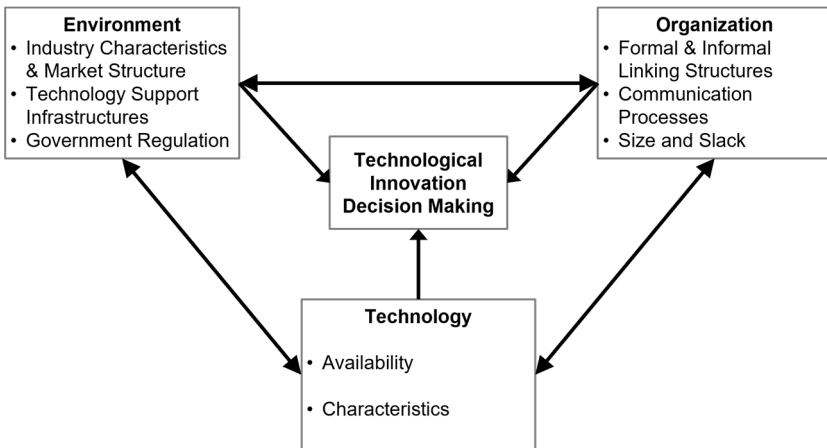


Figure 2-8: The TOE framework (Tornatzky & Fleischer, 1990, p. 154)

Developed by Rogers (1962) and Depietro et al. (1990), the technology-organization-environment (TOE) framework represents a theoretical model for studying the adoption of different types of technological innovation in organizations. It was first presented in the book *Processes of Technological Innovation* by Tornatzky & Fleischer (1990) to describe the innovation process and address how different elements of a firm's context influence the adoption of innovations (J. Baker, 2012). As seen in Figure 2-8, the elements refer to a *technological*, *organizational*, and

environmental context. Defined as an organizational theory, it provides a theoretical foundation and empirical support for various IS domains (T. Oliveira & Martins, 2011). Where the TOE framework focuses on a higher level of abstraction, additional behavioral models can be applied. The three elements provide “*both constraints and opportunities*” (Depietro et al., 1990, p. 154) and are further described as follows:

Technological context: The first element represents all technologies relevant to the firm, including associated practices, processes, and equipment. Such solutions can be either internal (e.g., already in use) or available on the market external to the firm (e.g., not currently in use) (T. Oliveira & Martins, 2011). Internal technologies address how firms cope with technology-induced change in the adoption process (Collins et al., 1988). External innovations provide insights by defining the ability of a firm to identify new technical possibilities to evolve and adapt (J. Baker, 2012). Such innovations can be further categorized according to their market implications. Where incremental and synthetic changes allow for an extended window of opportunity, discontinuous change requires fast and proactive decision-making (Tushman & Nadler, 1986). In addition, Baker (2012) concludes that adopting an innovation also needs careful consideration of the firm's core competencies.

Organizational context: The second element covers relevant firm characteristics such as intra-firm communication processes, strategic behavior of management, organizational structure, scope, and size (J. Baker, 2012). Various mechanisms influence communication and facilitate or impede decision-making. For example, individual business units or cross-functional teams that operate between departments can promote innovation. Also, executives and top management play a crucial role in establishing a culture that involves technological change as part of the company's vision (Tushman & Nadler, 1986). While decentralized organizational structures support technology adoption, aspects such as centralized decision-making might be more favorable for a target-oriented implementation. Larger companies tend to adopt innovation more likely, but existing research cannot clearly indicate a causality depending, for example, on the industry and market (J. Baker, 2012).

Environmental context: The last element refers to the external factors in which a company operates, including industry specifics, competitors, macroeconomic environment, regulatory and legal aspects (J. Baker, 2012). Following Tornatzky & Fleischer (1990), firms in fast-growing industries are more likely to innovate than those in declining industries. On the one hand, mature industries tend to introduce new technologies to achieve new levels of efficiency. On the other hand, cost reductions may force companies to avoid investments in innovation. Usually, new competitors are a good starting point for innovation to maintain a firm's competitive advantage (Teece, 2010). In addition, macroeconomic factors can lead to high wages for labor, increasing the pressure for new automated solutions (Levin et al., 1987). Also, regulatory changes can be either beneficial or detrimental to the individual firm. As a result, governmental decisions and laws (e.g., data privacy, air quality standards) may also accelerate or hamper innovation (J. Baker, 2012).

2.5.2 Applicability of the Framework in Research

The technological, organizational, and environmental context illustrates the relevant elements to investigate the adoption of innovations at the firm level. Thus, the overall TOE framework represents an appropriate structure for organizational analysis that has been widely used in extant research (Awa et al., 2017; J. Baker, 2012). Oliveira & Martins (2011) conducted a literature review and presented a comprehensive overview of empirical studies in the IS domain. The framework has been applied to explain the adoption of IT systems, especially in the area of electronic data interchange, enterprise resource planning, and e-commerce, using different descriptive methods and input data (Kuan & Chau, 2001; Y. Li, 2008). Besides various IT applications, a review by Baker (2012) further highlights the theory's role in understanding how a firm perceives and addresses new technologies according to its industry. With a focus on the secondary sector, several studies have been conducted in the service industry (e.g., health care, financial services) that demonstrate the applicability of the TOE framework across various cultural and regional contexts (Zhu et al., 2004). According to its broad acceptance, the model has shown a limited need for development since its

introduction in 1990 (J. Baker, 2012). It is considered a *generic theory* and is typically complemented with additional behavioral models (e.g., theory of reasoned action) to understand the adoption of technologies more individually. (T. Oliveira & Martins, 2011). A combination with other theories and the possibility of including additional factors based on the three proposed elements hardly suggest modifying the model.

The TOE framework is applied in this work to conceptualize the impact of asset tokenization in general and group selected challenges during its implementation in particular. The theory has been widely used to study different types of innovation and, therefore, provides a reasonable basis to investigate adoption on an individual firm level. The three defined elements add consistent empirical support to derive new descriptive measures about the tokenization concept and serve as a helpful starting point to gain insights into the specifics of the adoption in the financial services sector.

2.6 Literature Review and Research Gap

The lack of knowledge on how to operationalize and unlock the value potential of asset tokenization causes difficulties in the successful adoption of this innovation (Hartung et al., 2019). Accordingly, a literature review against the backdrop of the identified problem area is conducted to identify partial gaps in previous work. At first, the practical relevance is therefore addressed by defining the artifact's scope and purpose in terms of meta-requirements. The goal is to identify the relevant stakeholders and their needs to determine the problem domain. Based on these practical insights, the methodology by Vom Brocke et al. (2009) is applied to specify the research gap and the topic's relevance by examining the current state of the art. After the problem definition, the sections follow the steps of the literature review depicted in Figure 2-9, which includes five phases: (1) *define the scope of the literature review*, (2) *conceptualize the research topic*, (3) *search for literature*, (4) *analyze and synthesize research*, and (5) *derive the research agenda*. The review process is complemented by additional methods based on Cooper (1988) and Webster & Watson (2002).

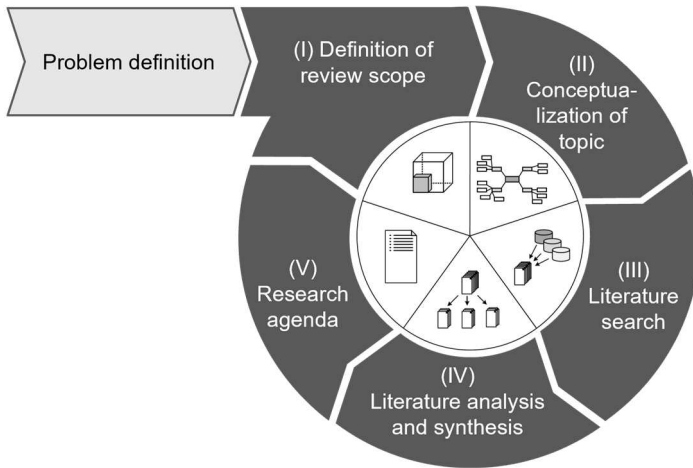


Figure 2-9: Literature review following Vom Brocke et al. (2009, p. 8)

2.6.1 Problem Definition

In the course of a DSR study, a clear understanding of the problem domain is required to address the solution space and derive relevant design objectives (Gregor & Hevner, 2013). Before conducting a systematic literature review, the current and desired state is identified. The dissertation generally focuses on a frame of reference to support business model innovation in the financial services sector. Based on its three artifacts, the goals are to (1) assess the business potential of tokenization, (2) to provide a set of elements to design a conceptual architecture for asset tokenization business models, and (3) to outline organizational principles for implementing such DLT-based platforms in the financial services sector. On that basis, practical insights have been derived during the CC Ecosystems to specify the purpose of the proposed artifacts. In particular, two focus group meetings (cf. CC8 WS1 and WS2) and a working group session (cf. WGI) have been conducted using semi-structured questionnaires and open-ended questions on the opportunities and challenges of DLT and tokenization (Appendix B.2).

The CC Ecosystem partner companies, for example, agreed on significant cost reductions and reduced lead times in using cryptocurrencies but pointed to complexities and difficulties identifying use cases other

than payment tokens. Against the backdrop of these challenges and opportunities, it was shown that there is a practical need for a framework that facilitates the development of asset tokenization business models. Therefore, the outcome of this research should address these aspects to increase industry acceptance. Based on these practical findings, three meta-requirements could be derived (Table 2-3), highlighting the problem domain and specifying the scope of the artifacts to be developed (Gregor & Hevner, 2013; Hevner, 2007).

Meta-requirements	Description	Exemplary Responses
MR1: Enable an understanding of application areas for tokenization	Missing understanding of use cases and lack of success stories requires an assessment of appropriate application areas to identify the business potential compared to conventional concepts and their underlying technology.	<i>"The biggest obstacle is the difficulty to determine benefits and potentials."</i>
MR2: Provide conceptual elements to establish token-based platforms or business models	Challenges in developing asset tokenization business models range from consortia building (e.g., structure, management & governance), integration of services, processes to uncertainties about the technical architecture.	<i>"The integration into existing systems [...], understanding and selecting a suitable technology is difficult."</i>
MR3: Identify transformational needs and guidelines for a successful adoption	Missing best practices, unknown transformational change (e.g., operating model), and existing regulatory uncertainties represent internal challenges that exacerbate the implementation of projects on a larger scale.	<i>"Solutions are currently not mature enough due to a lack of standards, where compliant security management for private keys [...] is a challenge."</i>

Table 2-3: Description of meta-requirements and selected responses

While real-world adoption has not kept pace with many investments, the derived meta-requirements foster the assumption that current practices cannot guide financial services firms through the changes necessary to innovate their business models. The meta-requirements may also indicate a general lack of research on asset tokenization. After addressing the problem area, a literature review is for that reason conducted. The investigation of the topic allows to draw on the existing body of knowledge and set the objectives for further research.

2.6.2 Scope of the Review

The literature review process is based on the guidelines by Vom Brocke et al. (2009), where the scope of the analysis is defined in the first step. Typically, literature reviews are used for many purposes and may follow an evaluative, exploratory, or instrumental approach. For example, the goal may lie in a systematic analysis of scholarly papers to answer a predefined research question or a high-level overview to evaluate a general research direction (Adams et al., 2007). The taxonomy by Cooper (1988), with its different criteria, represents an appropriate classification to facilitate the definition of the review scope. According to the problem statement and the presented meta-requirements, the research area of interest refers to *information systems research* and covers an interdisciplinary set of additional research domains. Within this area, selected themes from information technology (e.g., DLT, BC), business model research (e.g., business architecture), or management science (e.g., transformation) serve as a starting point for the overall analysis.

Characteristics		Categories			
(1)	focus	research outcomes	research methods	theories	applications
(2)	goal	integration	criticism		central issues
(3)	organization	historical	conceptual		methodological
(4)	perspective	neutral representation		espousal of position	
(5)	audience	specialized scholars	general scholars	practioners/ politicians	general public
(6)	coverage	exhaustive	exhaustive and selective	representatives	central/ pivotal

Figure 2-10: Review scope following Cooper (1988, p. 109)

The taxonomy is applied for this literature review in Figure 2-10 by highlighting selected categories alongside the six characteristics. The focus of the analysis (1) lies not on methods or theories but on research outcomes and applications to solve the challenges in the successful adoption of asset tokenization. In addition, current practice defines the terms around tokenization in sometimes conflicting ways. For that reason, the

review aims (2) to integrate existing findings and question the status quo. As the literature review summarizes and synthesizes existing knowledge, one goal is to (3) conceptualize the topic against practical insights. According to perspective (4), a neutral representation of existing findings is chosen to present the current body of knowledge as a basis for identifying the research gap. Next, the target audience (5) refers to specialized researchers and practitioners familiar with the concept of tokenization or the development of DLT or BC-based solutions. Lastly, the coverage of the literature (6) is intended to be both exhaustive and selective to draw on the existing body of knowledge and specify the objectives for further research in more detail.

2.6.3 Conceptualization of the Topic

As a second step, the conceptualization of the topic facilitates the identification of existing, missing, or underexplored areas of research in the review process (Torraco, 2005). For a broad conception, it is appreciated to provide working definitions and terms to address the relevant aspects of the study (M. Baker, 2000). According to Rowley & Slack (2004), concept mapping allows the visualization of central elements and their relationships to structure the concepts and keywords necessary for the subsequent search process. As shown in Figure 2-11, the concept map highlights the major aspects of the literature review and illustrates the initial research direction for approaching the topic of tokenization in the financial services sector.

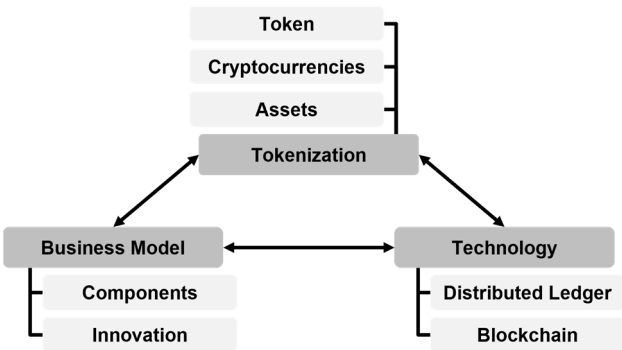


Figure 2-11: Initial conceptualization of the research topic

Due to the novelty of the research area, the practical requirements (cf. meta-requirements) serve as a starting point to investigate this phenomenon and its surrounding areas. As stated, firms have to rely on an effective business model to develop new products and services based on tokenization. As a central theme, the current state of the art is elaborated against the backdrop of existing *business model components* to operationalize solutions and unlock the value potential for new market outcomes. Another essential aspect of introducing new technologies is the innovation process. Accordingly, aspects of business model development commonly referred to as *business model innovation* are further considered. Another focus of interest lies in the technology used. *DLT* and *BC* enable the tokenization concept and provide a technical perspective on this application domain. Where tokenization is defined as the process of creating digital representations, the terms *token* and *assets* are also taken into account. In addition, *cryptocurrencies* share the same functionalities for asset transfer and complete the comprehensive search strategy. The conceptualization follows an initial understanding of the research area to specify the terms according to new insights obtained through additional literature reviews in this dissertation (Sections 3.2.1; 4.3.2; 5.2.1) (Rowley & Slack, 2004).

2.6.4 Literature Search

The literature search relies on the recommendations from prior research by Webster & Watson (2002). It is initially conducted by defining the following four search strings based on the conceptualization of the research topic: (*asset**), (*cryptocurrenc**), (*token**), (*tokenization*), all within the context of ("*blockchain***" OR "*distributed ledger***"). Next, appropriate databases for a topic-based search were selected. Vom Brocke et al. (2009) propose to query databases that cover renowned IS journals and ensure access to top-tier sources (e.g., proceedings of high-ranked conferences). As the conceptualization shows that tokenization covers an interdisciplinary set of different concepts, the goal is to include databases with publications focusing on computer science (e.g., IEEE Xplore) and business-oriented aspects (e.g., EBSCOhost, Science Direct). In addition, other platforms complement the review with

an emphasis on business informatics (e.g., AIS eLibrary, ACM Digital Library) and grey literature (e.g., ProQuest). As a result, the following databases have been selected: *EBSCOhost*, *IEEE Xplore*, *AIS eLibrary*, *Science Direct*, *ProQuest*, and *ACM Digital Library*.

Search string: ("blockchain*" OR "distributed ledger*") AND (...)	Search field	EBSCO- host	IEEE Xplore	AIS eLibrary	Science Direct	Pro Quest	ACM
<i>asset*</i>	Title & abstract	165 (119)	240 (172)	48 (34)	234 (188)	110 (65)	100 (44)
<i>cryptocurrenc*</i>	Title & abstract	254 (175)	244 (149)	36 (34)	402 (285)	137 (51)	83 (62)
<i>token*</i>	Title & abstract	83 (68)	237 (206)	21 (18)	80 (56)	53 (30)	64 (26)
<i>tokenization</i>	Full-text	41 (39)	29 (20)	47 (44)	13 (11)	48 (38)	22 (20)
Sum (After non- English removed)		543 (401)	750 (547)	152 (130)	729 (540)	348 (184)	269 (152)
Import into citation manager							1954
Sum (After title & abstract screening)							352
Sum (After full-text screening)							101

Table 2-4: Results of the literature search process

Table 2-4 shows the title & abstract search process conducted in August 2021 across the databases. The platforms are also queried by applying a full-text search of the term *tokenization* to increase the outcome of total hits (2791). After non-English articles were removed, 1954 results were imported into a citation manager to identify a steady trend between the terms *tokenization*, *cryptocurrencies*, *assets*, and *token* in the context of *BC* and *DLT* (Figure 1-1). Non-peer-reviewed articles (e.g., books, grey literature) were excluded to further analyze the relevance according to a title & abstract screening. More than three-quarters of all articles were removed before the remaining 352 sources were thoroughly screened by reading the introduction and conclusion. As a result, 101 papers are included in this review to draw first conclusions about the dissertation's topic. Additional forms of a backward and forward search, as suggested by Webster & Watson (2002), have been

neglected at this stage. Other reviews are conducted more specifically during the artifacts design process in the respective chapters to build upon or complement this final sample (Sections 3.2.1; 4.3.2; 5.2.1).

2.6.5 Literature Analysis and Synthesis

After the descriptive literature analysis (Section 1.1, p. 6), selected references are examined in more detail. Accordingly, the literature is synthesized and analyzed to generate new insights into the proposed research direction (Vom Brocke et al., 2009). The meta-requirements indicate a need for conceptual decision support to unlock the potential of asset tokenization as part of a broader business model for practitioners in the financial services sector. Thus, the business model concept with its components and innovation process steps provides an appropriate framing to describe the gap between the current state of the art and the desired target state. For that reason, a concept matrix is developed in Figure 2-12 to structure and facilitate the discussion (Salipante et al., 1982; Webster & Watson, 2002, p. xvii). In particular, the selected papers are assigned to the business model innovation phases by Frankenberg et al. (2013) to assess the article's practical utility in developing asset tokenization business models (i.e., ideation, design, implementation). In addition, a component-oriented business model view helps specify existing and missing contributions within a phase (e.g., *design* of the *technical architecture* for tokenization).

Previous research associated with tokenization shows that the concept is applied in various contexts and domains ranging from computer to management science. Scholars address this new phenomenon primarily from a business or technology-oriented perspective. For example, Ross et al. (2019) investigate the technical maturity of BC to support a functional platform for the tokenization of assets. Sazandrishvili (2020), on the contrary, provides a basic understanding of business potentials and insights for management executives.

Research that provides insights into the applicability of tokenization to assist ideation of innovative use cases in practice is separated into

token classification approaches and single application areas. The first topic focuses on classifications describing the various features of cryptocurrencies and cryptographic assets. Oliveira et al. (2018) present a holistic taxonomy to distinguish tokens from one another but neglect outcomes for applying tokens as part of a broader business model. According to application areas of tokenization, only selected publications are available. Roth et al. (2019) investigate one specific use case in equity crowdfunding, whereas other scholars also refer to applications in banking (Harwood-Jones, 2019; Sazandrishvili, 2020) or logistics (Babich & Hilary, 2020).

For the design phase, existing work on conceptualizing token-based platforms and underlying business models remains scarce. On the one hand, previous work relates to frameworks that capture the network setup or the generic BC ecosystem with different actors and roles (Risanow et al., 2018; Seebacher et al., 2021). On the other, only selected aspects such as governance or technical requirements for decentralized platforms are discussed in more detail (Beck et al., 2018; Ross et al., 2019). So far, a blueprint or a representative architecture with relevant business components (e.g., value network, value chain processes) for an efficient design is still missing.

Insights into organizational implications and guidelines for successfully implementing DLT-based solutions at the individual firm level remain largely unclear. The research is mainly based on two perspectives, namely *inter-organizational* and *intra-organizational*. The first perspective addresses the adoption of DLT-based platforms at the inter-organizational level, such as developing joint mechanisms for decentralized coordination within business ecosystems (Zachariadis et al., 2019; Zavolokina et al., 2020). The second perspective investigates intra-organizational challenges and highlights the required operational capabilities to successfully integrate DLT into existing business processes and settings internal to the firm (Kannengießer, Lins, & Sunyaev, 2020; Mendling et al., 2018). Hartung et al. (2019) present a target operating model for managing high-quality liquid assets with practical insights, but most references still explore the general applicability of the concept.

Selected References	Ideation			Design			Implementation	
	Token Classification	Use Cases	Business Potential	Network & Roles	Services	Technical Architecture	Best Practices	Capabilities
Oliveira et al. (2018)								
Roth et al. (2019)								
Ross & Jensen (2019)								
Sazandrishvili (2020)								
Riasanow et al. (2018)								
Harwood-Jones (2019)								
Hartung et al. (2019)								
Mendling et al. (2018)								
Research Objective								

Full Coverage
 High Coverage
 Medium Coverage
 Low Coverage
 No Coverage

Figure 2-12: Literature analysis and thematic coverage of the research topic

2.6.6 Research Agenda

The findings of the literature analysis and synthesis are transferred into a research agenda as a final step of the review process (Vom Brocke et al., 2009). The goal is to address both the practical needs based on meta-requirements and the gaps in the existing literature to underline the relevance of the overall research objective. Despite its first appearance in 2017, it can be stated that the topic of tokenization shows growing relevance for the scientific community. The number of publications is steadily increasing, with more than 170 publications since then. As tokenization follows the functionalities of cryptocurrencies to be issued, stored, and traded electronically via a DLT, the phenomenon can be interpreted as part of the DLT and BC research stream within the IS domain. Accordingly, the topic is still largely under-researched compared to other associated fields of study (e.g., cryptocurrencies) or the number of grey literature available.

Against the backdrop of the identified practical requirements (i.e., meta-requirements) of CC Ecosystems partner companies, three main findings can be further presented. Firstly, it can be stated that most scholars solely focus on technological or conceptual problems and neglect an integrative perspective for this application area so far. Secondly, there is a one-sided focus on the financial industry and the potential of DLT to improve existing structures rather than support the development of new innovative services. Although various sectors may benefit from this new concept, it is appreciated to bridge the gap toward interdisciplinary areas. The third major research gap relates to missing practical contributions, which assist practitioners in designing and implementing innovative solutions. Especially the conceptualization of specific business model components in terms of a tokenization value chain, network, or process model has not been examined so far. In addition, guidelines that anticipate required transformation to initiate change and overcome internal resistance have not been addressed yet.

Firms are encouraged to develop unique business models around technological innovations to realize their full potential. Based on these findings, research on tokenization should provide insights into why asset tokenization should be addressed and how design and implementation can be approached. In other words, it is highly appreciated to support practitioners in the ideation, design, and implementation of asset tokenization business models. It can be concluded that the three introduced research questions (Section 1.2, p. 8) address this scope to extend the current body of knowledge and close existing gaps in practice and academia. The tokenization of assets raises many critical questions for society, governments, and companies. As a result of this literature review, it is assumed that there are no clear answers yet.

2.7 Chapter Summary

The chapter focused on two major aspects by introducing this study's fundamentals and illustrating the relevance of its problem area. Firstly, the sections laid the foundation for an understanding of DLT, tokenization, and financial intermediation and introduced business model

research and the TOE framework as the theoretical foundation. Secondly, the practical need and gaps in existing work were identified to specify the subject of study and highlight the contribution of this work.

As a result, tokenization is defined as the process of creating a unique identifier using DLT in the form of a token that may digitally represent anything from valuable objects and contractual rights. Economically motivated, the concept can be applied for operational efficiencies and new innovative services in asset tokenization business models. Moreover, it is assumed that its impact on existing financial market infrastructures can pose both opportunities and risks for financial intermediaries, especially for transferring asset ownership with conventional IS.

In addition to the theoretical foundation, the practical relevance of the proposed framework was explored by defining the dissertation's scope based on three meta-requirements. Following these practical insights, a literature review of related work at the intersection of tokenization, business models, and technology was conducted. Finally, the findings justify the research objectives of this thesis, in which the three developed artifacts contribute to the existing body of knowledge and address existing gaps in both practice and academia.

3 The Business Potential of Asset Tokenization

To extend the understanding of application areas for tokenization in practice, insights into the generic business potential of this innovation are required (Section 2.6.1). While everything from art, diamonds, real estate, even oceans or stars may be tokenized, the concept can be utilized for many purposes and is not limited to the trading of digitized objects. To illustrate how firms can apply the various opportunities beyond one specific scenario, the chapter introduces a holistic framework to assess the business potential based on different assessment criteria and archetypical use cases. The following sections describe the results and present the first artifact of the dissertation in accordance with preliminary work by the author (Heines, Dick, et al., 2021). At first, related research about the business potentials of tokenization is discussed. Building upon this knowledge, the iterative steps for developing the artifact are explained in the second section. The third section demonstrates the assessment framework, its elements, and its use in practice. Additionally, the last section introduces eight empirically founded archetypes by applying the identified criteria in a morphological analysis based on 129 companies associated with tokenization.

3.1 Overview of Related Work

Existing work exploring the business potential of asset tokenization remains scarce (Section 2.6.5). Due to the vast number of use cases ranging from logistics to finance, decision-makers are faced with almost endless opportunities with no clear answers to which extent products, services, or business models might be innovated. Depending on the use case, the role of a token and the reason for using tokenized assets can significantly vary. Therefore, defining the business potential requires an understanding of both token properties (e.g., native token, non-fungible token) and use-case-specific aspects (i.e., drivers and barriers of tokenization). To the best of the author's knowledge, existing decision-aid tools (e.g., token standards) have fallen short of taking

these two factors into account. Based on the initial literature review in Section 2.6.5, previous work on business potentials focuses on two separate research streams: *token classifications* and *application areas of tokenization*. The first stream relates to various taxonomies and approaches to differentiate cryptographic assets based on different criteria and perspectives (e.g., technical, legal) to establish a common understanding of token designs and implementation (Ankenbrand & Bieri, 2018; Ketz & Sandner, 2019). The second stream deals with the applicability of tokenization in the context of specific use cases ranging from finance (Harwood-Jones, 2019), to health (Zhou et al., 2019), and other industries. To assess the business potential, it is necessary to unify both research streams and build upon relevant criteria for tokenizing an object (e.g., financial assets as fungible tokens) and its role in a business model (e.g., reduced costs in settlement). The following subsections summarize this knowledge to discuss and provide a foundation for the subsequent development of the artifact.

3.1.1 Token Classifications

Although the application areas of DLT have been extensively discussed in IS literature, research on tokens has become a growing subject of interest due to the widespread adoption of cryptocurrencies. In recent years, the possibilities of designing DLT-based tokens have increased in numbers and complexity. Several scholars have attempted to classify tokens and identify their functions, properties, or attributes by describing types. Oliveira et al. (2018) distinguish tokens across four dimensions: *purpose*, *governance*, *functional*, and *technical*. Based on a literature review and empirical data, 13 different parameters and associated sub-criteria specify these functional and technical aspects (e.g., representation of an asset as a digital, physical, or legal token). To describe the ambiguous nature of tokens, Euler (2018) proposes another descriptive classification according to five categories: *purpose*, *utility*, *underlying value*, *legal status*, and a *technical layer*. However, the criteria mainly follow attributes of cryptocurrencies as a sub-set of tokens and show only limited generalizability. Common to these approaches is an attempt to categorize existing cryptoassets guiding the design of tokens

with specific functionalities. However, a distinct and grounded understanding of the practical potentials and implications of tokenization is still limited. In this regard, a comprehensive approach is presented by Freni et al. (2020). Based on a comparative assessment of existing classificatory frameworks, four domains and 16 subdimension are selected to enable more than 41 million possible configurations (Freni et al., 2020, p. 6). The classification is then applied during a morphological analysis to identify a token's key role within token-enabled ecosystems that point out the potential in shifting from economics to tokenomics. Ankenbrand et al. (2020) introduce an industry-specific taxonomy and combine characteristics of traditional financial assets with the properties of cryptoassets. As a result, 14 attributes (e.g., claim structure, total supply, redemption, and transferability) are described to establish a common terminology for different stakeholders in the financial services sector (e.g., investors, brokers). The contribution suggests an integrative approach towards token standards (e.g., tokens for private and permissioned DLTs) to accelerate firm adoption in more regulated sectors.

Apart from scientific contributions, many industry-oriented classifications extend the perspective on tokens by adding criteria from a legal or business-related perspective. For example, Mueller et al. (2018) consider three token classes: *native utility*, *counterparty*, or *ownership token*. Especially the existence of a legal counterparty for an underlying asset represents the basis for a subsequent categorization to comply with the prevailing legal and regulatory frameworks. Different initiatives also drive new market standards for industry collaboration in a global token economy. For example, the International Token Standardization Association (ITSA) aims at an open market standard to facilitate identifying and comparing tokens along four generic dimensions: *purpose*, *industry*, *technological setup*, and *legal claim* (Ketzer & Sandner, 2019). The Inter Work Alliance attempts to establish a similar initiative to foster interoperability in several industry domains (e.g., insurance, healthcare, or real estate) for inter-organizational operations and distributed applications. By identifying the technical features and behaviors of tokens within a specific application area, patterns are defined that increase

collaboration and bridge the gap between different stakeholders (e.g., developers, projects managers, or regulators).

The review of existing classifications shows that most frameworks follow similar criteria (e.g., technical setup, token supply). Besides a shared understanding of a token's attributes, functions, and properties, the classifications reduce complexity for a practical token design (e.g., predefined properties of non-fungible tokens). Dependent on the target audience, the frameworks often focus on business-, regulatory- or technically oriented aspects. However, research on the practical implications of tokenized assets is still somewhat limited or neglected. A perspective beyond token characteristics is necessary to identify the role of tokenized objects as part of a broader business model and assess the business potential for a specific use case. While firms aim to explore new solutions in a token economy, questions arise about a token's purpose and benefits. As a result, new knowledge and decision support in this area will be required.

3.1.2 Application Areas of Tokenization

It is assumed that asset tokenization may transform existing infrastructures and enable innovative services for frictionless collaboration and higher efficiencies in many industries. However, missing real-world solutions lead to an insufficient understanding of the benefits and challenges. Accordingly, there is an increasing body of knowledge based on grey literature (e.g., blogs, reports, white papers) and few scientific contributions which explore the drivers and barriers for specific use cases. For instance, Narayan & Tidstrom (2020) investigate the role of tokens in a circular economy to operationalize and optimize cooperation across different stakeholders. In this case, tokenization enables an ecosystem to incentivize and facilitate collaboration between isolated platforms to support collective ideation and innovation. Lotti (2019) explores the benefits of tokenized art and identifies potentials through the disintermediation of existing value chains. Art tokens enable new opportunities to democratize the art industry, incentivize painters, and eliminate trusted third parties based on crypto-economics. Other

application areas relate to the tokenization of information or documents stored and managed digitally by a DLT-based platform. Babich & Hilary (2020) introduce claim tokens in operations to improve the administration, exchange, and trade of goods between various participants across the supply chain. By storing medical data as an entire data set on a distributed ledger, Zhou et al. (2019) discuss the potential of on-chain tokens for secure and efficient data processing.

Without relying on mediation by an intermediary anymore, use cases associated with the issuance, transfer, and storage of tokens on DLT-based platforms are expected to be highly disruptive for established market infrastructures in the real estate or the financial services sector (e.g., land registry, clearing, and settlement). Its relevance is also reflected by the surge of publications and the number of initiatives and pilot projects. Accordingly, several scholars refer to the tokenization of bankable assets to improve the management of asset ownership. In particular, the possibilities for automation (e.g., smart contracts), transparent record-keeping, and trusted reconciliation between parties (Hartung et al., 2019; Ross et al., 2019). Shtybel (2019) investigates the impact of DLT on capital markets infrastructure. Tokenized private securities are introduced to improve issuance, trading, and settlement to overcome existing inefficiencies. Besides transforming existing structures, tokenization also offers new products by creating liquidity in otherwise untradable asset classes (Harwood-Jones, 2019). Commonly referring to the tokenization of non-bankable assets, Sazandrishvili (2020) describes use cases for tokenized equity, intellectual property, as well as art and collectibles.

Although these opportunities seem promising, there are also common barriers to widespread adoption. The obstacles typically relate to a lack of technical standards, compliance requirements, or cybersecurity threats, to name a few (Harwood-Jones, 2019; Sazandrishvili, 2020). In particular, legal aspects and transition risks must be considered individually for a given use case. For example, Savelyev (2018) highlights two main problems in overcoming legal challenges. Firstly, the potential shift of national civil rights legislation towards a legal framework for

tokenized objects on a global scale. Secondly, the representations of rights (e.g., ownership rights) embedded into tokens and the enforcement of such rights in the event of violations have to be clarified (cf. legally binding smart contracts).

Following this brief study, it can be stated that previous research on application areas, benefits, and challenges of tokenization is limited and often refers to grey literature. However, the applicability of tokens is discussed in very general terms with a one-sided focus on the financial sector and process innovation in existing market infrastructures. Although various industries may benefit from this new concept, there is no systematic overview of use cases in an interdisciplinary context. Therefore, it is appreciated to address this gap and highlight multifaceted applications to guide practitioners in business model innovation.

3.2 Development of the Assessment Framework

For developing the artifact, a three-step research approach is defined based on the DSR methodology by Hevner et al. (2007). The goal is to conduct iterative design cycles (i.e., build, demonstrate, and evaluate) to ensure close feedback loops with practitioners and address an applicable IT artifact for the identified problem area. Following the general approach of DSR (Gregor & Hevner, 2013; Peffers et al., 2007), the first iteration consists of secondary data collection and analysis to identify an initial set of dimensions and sub-criteria relevant to assess token-based solutions in extant literature (Braun & Clarke, 2006; Webster & Watson, 2002). To validate the findings from the review, a second iteration is introduced by including primary data based on 25 semi-structured interviews. Thus, the assessment framework is refined with experts from the financial services sector and associated areas (e.g., C-level executives, project managers) by applying methodological recommendations from prior research (Ayres, 2008; Gioia et al., 2013). Following the consortium research approach, the final artifact is presented, challenged, and discussed in a third cycle to evaluate and demonstrate its overall applicability.

3.2.1 First Iteration

For the first design cycle, an initial set of criteria is required that outlines the business potential and enables an assessment of use cases in the context of asset tokenization. Therefore, both attributes of tokenized objects and aspects that indicate the applicability as part of a broader operating and business model have to be identified. Accordingly, the development of the assessment framework started with an analysis of the existing body of knowledge by means of a structured literature review (Webster & Watson, 2002). For identification of relevant articles, six scientific databases were searched in September 2020 (i.e., EBSCOhost, IEEE Xplore, AIS eLibrary, Science Direct, ProQuest, and ACM Digital Library) using the following search string in a title and abstract search: *("blockchain*" OR "distributed ledger*") AND (token*)*. A full-text search for *("tokenization" OR "tokenisation")* was also considered to increase the completeness of the review. The search returned a set of 214 documents. After addressing only peer-reviewed articles, the title, abstract, and keywords were further analyzed to identify the results relevant to the research objective. Duplicates and non-English publications were excluded before an additional full-text screening was conducted. Thus, the remaining 23 articles set the basis for a forward and backward search to extant the theoretical contributions with practical findings. In sum, 34 publications have been selected that address the business potential of asset tokenization. The initial concept matrix of the literature review is further presented in Appendix D.1.

In the next step, the final papers are analyzed to identify relevant criteria based on thematic analysis by Braun & Clarke (2006) and the phases: *familiarize yourself with the data, generate initial codes, search for themes, review themes, define and name themes, and produce the report*. Following these steps, relevant documents were read carefully to identify potential dimensions that may describe the applicability of asset tokenization at first. Next, different dimensions for the initial codes were brainstormed. After searching for themes within the predefined dimensions, the outcome was refined in discussion rounds among researchers. Accordingly, the following three themes were specified: (1) *token*

attributes, functions, and properties, (2) value drivers, potentials, value propositions, and benefits of tokenization, as well as (3) challenges, limitations, and barriers of tokenization. During the analysis, the identified codes were further adapted to align different levels of abstraction and overcome shortcomings in applying the identified themes. As a result, too distinct properties (i.e., burnability, expirability, issuance) were neglected. Also, related criteria to assess the degree of applicability (e.g., real-time processing, process automation) and similar aspects for evaluation (e.g., facilitated access, democratization) were merged or summarized. Initially, 21 dimensions with 76 sub-criteria were identified for this first iteration.

3.2.2 Second Iteration

An explorative approach based on semi-structured expert interviews is chosen for the second cycle to complement the initial findings and validate the identified dimensions and sub-criteria (Ayres, 2008; Gioia et al., 2013). The participants were either members of the CC Ecosystems or contacted due to their tokenization project experience on LinkedIn. In total, 25 interviews were conducted in three interview rounds regarding the tokenization of assets, potentials, implications, and use cases (Table 3-1). In addition, the interviewees from 19 companies were mainly affiliated with the financial services sector (e.g., financial services, IT service providers, and professional services) but showed interdisciplinary backgrounds to sufficiently represent the current state of the tokenization ecosystem.

An interview guide was sent to the participants in advance, where the interviews lasted between 52 minutes on average (Appendix D.2). Each interview was recorded, transcribed, and complemented with additional notes. During the first rounds, the goal was to understand the problem area clearly and address the perceived benefits and challenges of tokenization using open-ended questions. After finding similarities in consecutive interviews regarding the insights into the applicability of tokenization (e.g., fractional ownership, automated settlement), the open structure of the interview guide was adapted.

Regarding the second interview round, the experts should directly challenge the assessment criteria of the framework. Instead of replying to open-ended questions, the participants actively applied the artifact according to an exemplary use case from their domain. Based on the qualitative research approach by Gioia et al. (2013), the transcripts were analyzed using first-order concepts and second-order themes to identify confirmatory, contradictory, or complementing aspects of the framework. As a result, new dimensions on token properties were added (e.g., token supply), sub-criteria on token representations were refined (i.e., digital, physical, contract), and redundant aspects (e.g., technical complexity associated with oracle problems) were merged.

Interview Round	Goals of the Interview	ID	Function of the Interviewee	Affiliation	Company Size
1st Interview Round	Understanding of the problem domain, identification of value potentials and barriers of tokenization	B1	Head New Markets	Bank	Medium
		D1	Co-Head Clients	Digital Asset Bank	Medium
		D2	Head Token Platform	Digital Asset Bank	Medium
		L1	Lawyer & Founder	Legal & Tax	Medium
		L2	Swiss Senior Legal & Regulatory Expert	Legal & Tax	Large
		F1	Co-Founder & Chief Investment Officer	FinTech	Small
		P1	Head of Fintech	IT-Provider	Large
		P2	Manager Technology	IT-Provider	Large
		P3	Manager Tokenization Services	IT-Provider	Large
		D3	CEO & Head Crypto Payments	Digital Asset Bank	Medium
		E1	Product Manager	Exchange	Large
		S1	Business Development	Start Up	Small
2nd Interview Round	Reevaluation of prior results, refinement of the framework and identification of tokenization use cases	D4	Chief Client Officer	Digital Asset Bank	Medium
		F2	Chief Executive Office & Founder	FinTech	Small
		F3	Chief Executive Office & Founder	FinTech	Small
		B2	Project Manager	Bank	Large
		R1	Researcher	Research	Medium
		F4	Chief Sales Officer	FinTech	Medium
		F5	Chief Executive Office & Founder	FinTech	Small
		D5	Head of Business Unit	Digital Asset Bank	Medium
		F6	Chief Marketing Officer	FinTech	Medium
		D6	Board of Directors	Digital Asset Bank	Medium
		L3	Consultant	Legal & Tax	Small
		F7	Co-Founder & Head Business Analytics	FinTech	Small
3rd Interview Round	Evaluation of Final Results	F8	Chief Operating Officer	FinTech	Small

Table 3-1: Overview of interviews

While the last three consecutive interviews added no new insights, it could be assumed that a particular theoretical saturation was reached. Therefore, the third interview round finalized the primary data collection for the artifact's design and development, resulting in a preliminary framework with 12 dimensions and 44 sub-criteria.

3.2.3 Third Iteration

In a third cycle, further practical insights were derived during the CC Ecosystems to reevaluate the artifact with the partner companies. Specifically, the framework was demonstrated in a workshop and discussed in a focus group meeting (cf. CC9 WS1) using a structured discussion guide. The company representatives regularly participated in the consortium research sessions and, thus, shared a general understanding of the topic. By following the evaluation criteria by Sonnenberg & Vom Brocke (2012), the discussion should address the *completeness, fidelity, consistency, level of detail*, and *robustness* of the framework for assessing the business potential of tokenization and its different criteria. The virtually conducted workshop was recorded, transcribed, and subsequently analyzed (Gioia et al., 2013).

The findings indicated that the artifact meets both applicability and usefulness for the financial industry and general areas in innovation or IT strategy: “[...] *For me, it is a useful grid and gives a good orientation.*” (*Product manager*). Also, the growing need to understand new application areas of asset tokenization could be addressed: “[...] *Not every company has a consultant who can help with these issues [...], so if you can get an overview or a guideline, that is very, very useful.*” (*Innovation manager*). In addition, the participants widely agreed on the consistency and robustness of the artifact’s dimensions (e.g., driver and barriers of tokenization) but also pointed out the possibilities to further specify sub-criteria, such as *regulatory & legal* as well as *legacy structures & transition risk* in further design iterations: “*It is a mix of both. [...] On the one hand, we have regulatory frameworks, which of course, have to be examined. On the other hand, there are also the technical aspects [...] you have to realize that there is not much know-how available, and that is exactly the difficulty of promoting new services.*” (*Business developer*). Regarding completeness, it cannot be fully claimed that the artifact is fully finalized or stops the need for future research. Finally, the practitioners agreed that the assessment framework provides a sound foundation with relevant distinctions to define the business potential and complements existing approaches for structured ideation.

3.3 Assessment Framework for Asset Tokenization

Based on a literature review and practical insights, the comprehensive assessment framework for the tokenization of assets is illustrated in Table 3-2. The first column consists of the dimensions related to the respective criteria, which are then applied to evaluate the business potential of a proposed use case. At first, the following sub-sections provide an artifact description based on three overarching themes and their respective sets of criteria associated with *token properties*, *value drivers*, and *barriers for tokenization*. After defining the 12 dimensions and 44 sub-criteria, the chapter closes by explaining how the artifact can assist firms in aligning potential trade-offs and assessing the applicability of a specific asset tokenization use case.

Dimension	Criteria								
Tokenized Representation	e.g., Art		e.g., Gold		e.g., Votes		e.g., Shares		e.g., Membership
Industry Focus	Financial & Insurance	Prof. Sci-entific & Technical	DLT-specific Application	Transport & Storage	Arts, Entmt. & Recreation	Wholesale & Retail Trade	Information & Comm.	Public Adm. & Defense	
Underlying Representation	Digital			Physical			Contract		
Function	Access to a Service	On-Chain Reward Potential	Off-Chain Cash Flow & Dividend	Store of Value	Collectibles	Means of Exchange	Voting Right		
Purpose	Payment Tokens			Utility Tokens			Asset Tokens		
Unit	Fractional			Whole			Singleton		
Tradability	Transferable				Non-Transferable				
Fungibility	Fungible				Non-Fungible				
Supply	Fixed				Unfixed				
Technical Setup	Ledger Native				Ledger Non-Native				
Driver of Tokenization	Democratiza-tion & Facilitated Access	Increased Liquidity		Disinter-mediation	Increased Transparency		Process Optimization		Digital Scarcity
Barriers of Tokenization	Legacy Structures & Transition Risk		Data Privacy		Regulatory & Legal		Governance Issues		Oracle Problem

Table 3-2: The assessment framework (Heines, Dick, et al., 2021, p. 6)

3.3.1 Token Properties

The theme *token property* consists of all dimensions and criteria to specify how a tokenized object can be represented and characterized within a specific use case in the form of a token. Accordingly, it serves as a starting point for a distinct analysis, comparison, and discussion of different manifestations and designs of a token.

Tokenized Representation: The dimension specifies the reference, value, asset, or proxy represented by the token and serves as a placeholder for the tokenized object. While, defacto, anything may be represented digitally in the form of a unique singular identifier on a distributed ledger, tokenized representations can range from valuable assets (e.g., art, gold, credit loans) to contractual rights (e.g., ownership right) in myriads manifestations.

Industry Classification: A tokenized object can be assigned to an industry according to its application, use case, or as part of a product, service, or process. The industrial groupings are based on the UK Standard Industry Classification (SIC), where the sub-criteria cover eight industries. For example, *Financial and Insurance* (e.g., Cryptocurrencies), *DLT-specific Applications* (e.g., DApp token), *Transportation and Storage* (e.g., provenance token), *Arts, Entertainment, and Recreation* (e.g., Video Game token) (Marshall et al., 2018).

Underlying Representation: The property generalizes the tokenized representation and refers to the underlying nature of the token according to three abstract groupings. Firstly, *digital* references, such as bankable assets and cryptoassets, already exist in digitized form. Secondly, *physical* objects as tangible references (e.g., classic cars). Thirdly, *contract* in terms of tokenized agreements (e.g., usage rights) as an additional form of an intangible underlying (L. Oliveira et al., 2018).

Function: The dimension describes the reason for holding a token and is specified according to seven sub-criteria based on the functionalities of a token: *access to a service* (e.g., discount), *on-chain reward potential* (e.g., staking), *off-chain cash flow* (e.g., dividends), *store of value*

(e.g., gold), *collectibles* with intrinsic value (e.g., stamps), *means of exchange* (e.g., currency), and *voting right* (Marshall et al., 2018).

Purpose: A token can be classified according to an economic purpose for achieving the following three objectives: *Payment tokens* used as a means of payment or value transfer (e.g., Bitcoin). *Utility tokens* for access to applications or services via a DLT-based infrastructure (e.g., Ether). *Asset tokens* (cf. security tokens) to represent, for example, the ownership or claim against an issuer for a share in future company earnings or capital flows (e.g., Crowdlitoken) (Mueller et al., 2018).

Unit: The property describes the ability of a token to be sub-divisible into smaller fractions based on the three sub-criteria: *Fractional*, *whole*, and *singleton*. The number of fractional tokens is usually represented as decimals and can be broken down into smaller fractions. Whole tokens are not sub-divisible, often referring to the original unit of the underlying representation. Singleton has a minimum quantity of one and also allows no subdivision (InterWork Alliance IWA, 2020).

Transferability: The dimension defines the transferability regarding, for instance, the transfer of ownership from one party to another. A token can be transferred on a trading platform (e.g., some types of registered securities) to be considered *transferable*. Otherwise, it is *non-transferable*, for example, in the case of digital identities or sensible data legally binding to only one bearer (L. Oliveira et al., 2018).

Fungibility: The ability of a token to be interchangeable with another one of the same type based on the two sub-criteria: *fungible* and *non-fungible*. A fungible token has an interchangeable value with one another, where any quantity has the same value as another equal quantity of the same token class. Hence a non-fungible token is unique and cannot be interchanged due to different values (L. Oliveira et al., 2018).

Total Supply: The property specifies the number of tokens generated according to its entire token supply, namely *fixed* and *unfixed*. Fixed supply indicates that the total supply of tokens is capped. However, an

unfixed token supply is not limited, managed flexibly by authorized parties (e.g., discretionary), or dependent on meeting predefined conditions (e.g., schedule-based) (Ankenbrand et al., 2020).

Technical Setup: A token can be classified according to its operating layer within the DLT to be separated into: *native* or *non-native*. A ledger native token (e.g., Bitcoin, Ethereum) is implemented into the protocol layer and is embedded as an integral element of the DLT infrastructure. A non-native token is built upon the protocol layer and on top of an existing distributed ledger, often utilizing a predefined token standard (e.g., ERC-20) (Ketz & Sandner, 2019).

3.3.2 Drivers of Tokenization

The perspective beyond token properties is extended in terms of six *drivers of tokenization* to clarify the role of tokenized objects and to identify why tokens are applied as part of a broader operating and business model. Each sub-criteria within this category can be chosen more than once if one or more of the following drivers explicitly apply.

Democratization & Facilitated Access: The criterion applies when financial inclusion should be achieved by democratizing the access to capital and expanding the potential investor base via tokenization. Fundraising is often reserved for a selected group (e.g., angel investors, venture capitalists), inefficient due to high administrative requirements (e.g., various documents, due diligence), and highly localized (closed communities and networks). However, tokenization lowers the barriers by enabling users to participate more easily (e.g., P2P lending, ICOs).

Increased Liquidity: Tokenization reduces friction by releasing trapped liquidity in otherwise untradeable asset classes such as unlisted bonds, real estate, and collectibles (e.g., art, wine). The concept facilitates the transfer of ownership (e.g., settlement without a third party) to enable round-the-clock market access. Additional liquidity can be further generated through fractional ownership and smaller units of investments (Harwood-Jones, 2019; Shtybel, 2019).

Disintermediation: Based on DLT, tokens can be traded between buyers and sellers directly without additional third parties, reducing the need for trusted intermediaries. Decentralized exchanges (e.g., Uni-Swap), P2P payments, and atomic settlements are examples of disintermediation of financial market structures. However, new functions may be required to bridge, for example, the existence between a digital token and its backed real-world object (Sazandrishvili, 2020).

Increased Transparency: Tokenization and its underlying DLT facilitate recordkeeping and reconciliation, providing transparency and traceability of transactions. It is assumed that a single source of truth for the management of asset ownership based on tokens can significantly improve efficiency and administrative efforts for all actors involved (e.g., investors, regulators) (Hartung et al., 2019; Shtybel, 2019).

Process Optimization: The criterion applies to the various features of DLT and describes the ability to improve interoperability (e.g., P2P architecture), increase systems availability (e.g., no-single point of failure), and automate business logic (e.g., smart-contracts functionalities). For example, in the case of market infrastructures, tokenization may provide real-time data and optimize corporate actions through automated dividend payments (Hartung et al., 2019; Shtybel, 2019).

Digital Scarcity: Tokenization introduces the concept of scarcity and limits the replicability of digital representations by using DLT to prevent tampering by malicious parties (e.g., double-spending of Bitcoins). It contradicts the common understanding that a digital medium can be easily altered and copied in the absence of trusted third parties (Chen, 2018; Lotti, 2019; Macedo, 2019).

3.3.3 Barriers of Tokenization

Besides token properties and drivers for adoption, it is also necessary to consider the risks of a project. As a result, five main adoption barriers are presented to reflect the business potential of token-based solutions in light of various challenges during realization. Accordingly, one or

more of the following barriers may be selected when evaluating a particular use case.

Legacy Structures & Transition Risk: Tokenization use cases rely on DLT-platforms (e.g., payment tokens) that often compete with established market infrastructures (e.g., SWIFT clearing system). The transition to a new solution and the efforts to integrate existing systems (e.g., core banking system) requires additional justification for high migration costs, unknown market outcomes, and operational risks.

Data Privacy: Due to the features of DLT, tokenization can become subject to data privacy concerns regarding transparency of transactions, decentralized accountability, and pseudonymity of cryptographic keys. Depending on the case, it is required to comply with existing standards and refine technical requirements. For example, in some jurisdictions, a citizen's right to erase personal data (e.g., right to be forgotten) contradicts the goal of a DLT to maintain immutable records (e.g., GDPR).

Regulatory & Legal: The barrier describes uncertainties towards legal compliance and legal interpretation of use cases. For example, specific governing frameworks apply to particular tokenized objects (e.g., equity tokens) that regulate the issuance of associated products and services on existing markets (e.g., securities supervision). Due to the novelty of the concept (e.g., ownership rights technically embedded into smart contracts), limited enforceability of rights, consumer risks, lack of global standards, and adaption of regulators have to be considered.

Governance: As tokens can be transferred without the mediation of one central party, new mechanisms, rules, or processes on an inter-organizational level are required to ensure, for instance, the joint accountability of the underlying DLT-based decentralized platform. Accordingly, the degree of complexity increases with the number of involved parties to set up, initiate, incentivize, and operate a so-called minimal viable ecosystem for tokenization.

Oracle Problem: The barrier addresses the difficulty of establishing a consistent interface between the distributed ledger and the outside world. In particular, it defines to what extent external data (cf. off-chain data) has to be gathered and embedded into a DLT-system to ensure the functionality of a tokenization use case. For example, a tokenized real-world object can only be authenticated by collecting data via additional hardware (e.g., Sensors, IoT devices) to consistently link the digital token to its physical counterpart (e.g., art token).

3.3.4 Assessment of Tokenization Use Cases

The presented artifact provides an abstract but useful basis for assessing tokenization and serves as a decision-aid tool to identify its business potential. In particular, practitioners can apply the given sub-criteria to ideate use cases and token-based business models based on different token manifestations, individual strengths, and potential weaknesses. This qualitative approach follows the three overarching themes, *token properties*, *value drivers*, and *barriers of tokenization*, which are applied in two steps.

At first, decision-makers must specify a use case according to the token property dimensions. In the context of the respective sub-criteria, the characteristics of a token are selected accordingly to illustrate the business case and establish a common understanding of the product or service associated with tokenization. The same tokenized object can have different purposes and functionalities depending on the chosen path. An example of a *tokenized classic car* for investment purposes is highlighted in grey in Figure 3-1. As a proxy for physical value, a classic car token can be traded on financial market infrastructures in the form of a commodity. For investors that seek new asset classes for diversification and protection against inflation, the token may serve as a store of value. Then, it can be defined as an asset token transferable by design. Instead of tokenizing a whole set of automobiles with the same traits, the classic car token refers to one unique model represented as a non-fungible token with a fixed supply. However, as the token does not specifically inhere a utility right, it may be split among different

investors considering implemented fractionality. Next, known DLT-infra-structures and token contract standards can be used (e.g., Ethereum).

Token Properties									
Tokenized Representation	Industry Focus	Underlying Representation	Function	Purpose	Unit	Tradability	Fungibility	Supply	Technical Setup
Classic Car	Financial & Insurance	Digital	Access to a Service	Payment Token	Fractional	Trans-ferable	Fungible	Fixed	Ledeger Native
e.g., Gold	Prof. Sci. & Technical	Physical	On-Chain Reward Potential	Utility Token	Whole	Non-Trans-ferable	Non-Fungible	Unfixed	Ledger Non-Native
e.g., Votes	DLT Specific Application	Contract	Off-Chain Cash Flow & Dividend	Asset Token	Singleton				
e.g., Shares	Transport & Storage		Store of Value						
e.g., Art	Arts, Entmt. & Recreation		Collectible						
	Wholesale & Retail Trade		Means of Exchange						
	Infomation & Commu-nication		Voting Right						
	Public Adm. & Defense								

Figure 3-1: Exemplary token properties for the tokenization of a classic car

After illustrating the token property dimensions, the use case is as-sessed against the backdrop of practical requirements for a successful realization. In the second step, decision-makers have to align further activities by identifying trade-offs between opportunities and risks. Spe-cifically, insights are derived to which extant different drivers and barriers apply. As shown in Figure 3-2, these two dimensions of the frame-work discern the pros and cons, where each sub-criteria provides an indication ranging from *high* to *low relevance* to judge the feasibility. According to a tokenized classic car, a token enables facilitated trade using DLT-based platforms and further reduces investment barriers to extend the investor base. Increased liquidity is also a driver for adoption caused by fractionalized investment denominations and decreased

market friction of tokens. Disintermediation further reduces transaction costs, whereas transparency, process optimization, and digital scarcity play a minor role in this exemplary case.

Drivers of Tokenization						Barriers for Tokenization				
Democratization & Facilitated Access	Increased Liquidity	Disintermediation	Increased Transparency	Process Optimization	Digital Scarcity	Legacy Structures & Transition Risk	Data Privacy	Regulatory & Legal	Governance Issues	Oracle problem
High Relevance	High Relevance	High Relevance	High Relevance	High Relevance	High Relevance	High Relevance	High Relevance	High Relevance	High Relevance	High Relevance
Medium Relevance	Medium Relevance	Medium Relevance	Medium Relevance	Medium Relevance	Medium Relevance	Medium Relevance	Medium Relevance	Medium Relevance	Medium Relevance	Medium Relevance
Low Relevance	Low Relevance	Low Relevance	Low Relevance	Low Relevance	Low Relevance	Low Relevance	Low Relevance	Low Relevance	Low Relevance	Low Relevance
No Relevance	No Relevance	No Relevance	No Relevance	No Relevance	No Relevance	No Relevance	No Relevance	No Relevance	No Relevance	No Relevance

Figure 3-2: Exemplary drivers and barriers for the tokenization of a classic car

However, it can be stated that difficulties arise as only licensed market actors might meet regulatory and legal requirements for issuing such kinds of tokens. While secondary markets for illiquid assets might barely exist and privacy concerns might be neglected due to limited sensible data, these two sub-criteria represent only a low barrier for this case. However, acquiring necessary business partners (e.g., car dealers, qualified experts for pricing) and the technical challenges in gathering external data represent major obstacles. As a result, a tokenized classic car for investment purposes might show high applicability with considerable business potential. Still, the use case must be reflected against legal and technical requirements to be met by existing regulations and the individual firm's resources (e.g., IT provider, retail bank).

The assessment framework with its relevant dimension and sub-criteria represents an initial approach for illustrating the generic tokenization concept based on the specification of use cases. Although the development of a quantitative decision-aid tool is beyond the scope of this dissertation, it presents a viable approach for future versions of this

artifact. In addition to individually weighted aspects, additional metrics can be considered that increase the accuracy of the outcome and improve the interpretation of results.

3.4 Archetypical Use Cases of Asset Tokenization

Besides assessing novel use cases, the artifact also allows a classification of tokenized representations as part of an existing business model. For that reason, the criteria represent a set of formal descriptions to uncover a range of scenarios and further demonstrate the business potential of tokenization in practice. Following a morphological approach, the assessment framework is applied in an empirical analysis using a sample of companies associated with tokenization (e.g., fintechs, startups, crypto banks). The various combinations of sub-criteria illustrate dependencies and highlight patterns of similar instantiations to derive archetypical use cases. In the first sub-section, the empirical approach and the analysis of the 129 firms are described. After highlighting the interrelations, dependencies, and patterns between token properties, drivers, and barriers of the various use cases, the chapter closes with eight identified asset tokenization archetypes.

3.4.1 Empirical Analysis

The artifact is applied in terms of a morphological box to identify patterns in various use cases associated with asset tokenization business models. Following this analytical approach by Zwicky (1969), an instantiation is assigned to specific parameters in the form of a grid box. This problem-solving technique is typically used for multi-dimensional questions and is appreciated to select and highlight similar sub-criteria of use cases in the assessment framework.

In the first step of the empirical analysis, a company screening was conducted to collect appropriate data using the following platforms: *crunchbase.org*, *chaineurope.org*, and *e-foresight.ch*. The selected databases display business information about private and public companies focusing on innovative startups and fintechs. The initial search

included firms associated with DLT and BC-based services in German-speaking Europe, such as Germany, Austria, Switzerland, and Liechtenstein. As a result, 183 company profiles from various industries (e.g., finance, logistic, retail) were identified, representing a diverse business ecosystem around tokenization. The subsequent data analysis included additional sources (e.g., company websites, press reports, business presentations, and whitepapers) to extend the knowledge base. However, only firms that utilize the tokenization concept as a central part of their operations or business model (e.g., asset tokenizer, token issuance services) were considered in the first place. On the contrary, services and products not associated with a specific tokenized representation, for instance, wallet providers, cryptocurrency exchanges, miners, or broader DLT-infrastructure such as Ethereum, were neglected. By additionally excluding incomplete company information (e.g., bankrupt firms), the data collection resulted in a final set of 129 firms.

Next, the predefined dimensions and sub-criteria of the artifact were assigned by applying coding schemes to the company information and their individual use case. In some scenarios, a single company offered multiple tokenization services, where each use case was assessed separately (e.g., token issuance of different collectibles). The process was conducted by a junior researcher (i.e., one year experience) under the supervision of a more experienced researcher (i.e., three years experience). The instantiations for each case were validated in different iterative rounds. The resulting disputes were resolved in group discussions (Strauss, 1987). Different patterns as frequent combinations of sub-criteria were identified based on the increasing number of instantiations. As a result, similar tokenization use cases were highlighted, showing a tendency towards eight final archetypes. Moreover, the empirical analysis demonstrated the utility and robustness of the artifact not only as a decision model but also as an analytical tool.

3.4.2 Patterns between Properties, Drivers, and Barriers

After reviewing asset tokenization use cases of 129 companies, the recurring patterns provide insights to conclude various interrelations and

dependencies. For instance, the tokenized representation of *bankable assets* was often associated with the token property *fractional*, and the driver *increased liquidity*, whereas *physical* objects often correlate with the barrier *oracle problem*. As a starting point for identifying such archetypical patterns, interdependencies between different sub-criteria are presented and structured according to their relevance in the following sections. The analysis starts with an interpretation of the tokenized object to further investigate the interrelationships regarding the three themes, properties, drivers, and barriers.

Tokenized representations and their properties: The empirical analysis revealed that the tokenization of *physical* assets (e.g., real estate, art) is primarily utilized in the *financial services sector*, *logistics*, and *arts industry*. On the one hand, tokenized minerals improve tracking and tracing in supply chains. On the other hand, tokenized paintings provide increased authenticity through a consistent ownership history. *Physical* high-value assets are often tokenized for investment purposes based on outstanding external value (e.g., gold, diamonds). This pattern shows similarities in tokenizing existing *digital* product offerings (e.g., bankable assets). Especially the tokenization of shares, bonds, and other securities is typically applied in the financial services sector, where a *fractional*, *transferable*, and *fungible* token design is required. Accordingly, tokenized bankable assets fulfill the function to exchange and store value and provide *off-chain* or *on-chain reward potentials* for the token holder. By tokenizing *contracts* (e.g., voting, usage rights), a strong dependency on platform or service access for various industries can be identified. For example, owning utility tokens grants access and service discounts and allows participation in decision-making processes. A tokenized usage right follows a *fungible* design and is characterized by an *unfixed* supply and *transferability*. However, other utility tokens are distinguishable because of their predefined token ownership. For instance, in the case of digital twins and identities, *transferability* and *fractionality* are not desirable. Instead, they are assigned to only one bearer and follow a capped token supply and non-fungible design. Also, for *collectibles* (e.g., diamonds, classic cars), a unique reference is established through a *non-fungible* token. Both tangible and

intangible assets are tokenized based on their features and properties. Especially virtual items for gaming (e.g., digital trading cards) follow a *fixed* token supply to create scarcity for a limited number of digital objects. *Transferable* assets are often represented by *non-native* tokens building upon public permissionless DLT-frameworks (e.g., Ethereum's ERC-20 standard), where only a few cases rely on proprietary systems. It is assumed that more complex *utility tokens* may require an extended functionality to be supported by custom applications and private permissioned DLT-designs (e.g., Corda).

Token properties and drivers for tokenization: The technical feature of DLT and the management of asset ownership based on tokens set the starting point for a distinct analysis of interdependencies between token properties and drivers for tokenization. On the one hand, the concept is applied to overcome drawbacks in existing solutions (e.g., costly intermediaries, long lead times). On the other, tokenization also offers the possibility to create new business opportunities that were not possible or not economically viable before (e.g., micropayments). The driver, *democratization & facilitated access*, is often associated with tokenizing *physical* assets. Compared to the tokenization of *contracts*, this interrelation shows less significance. Another pattern is identified between *increased liquidity* and the property *unit*. For example, real estate is tokenized to provide liquidity through a *fractional* token design. Especially for financial inclusion, tokenized equity and debt offer a viable solution to increase access to capital markets for a broader investor base. Some use cases (e.g., P2P lending) promote low investment barriers, particularly tokens for non-bankable assets, which are typically considered illiquid (e.g., art, watches, and wine). Besides these benefits in product innovation, it is assumed that the financial service sector utilizes the tokenization concept to primarily enable *process optimization* and *increased transparency*. This combination usually refers to the automation of corporate actions using smart contracts and tamper-resistant records of transactions. Especially the tokenization of currencies is often motivated by *disintermediation*. Therefore, it is assumed that clearing and settlement without a third party are highly beneficial for a *means of exchange* (e.g., stable coins). However, this pattern is not identified

for tokenized *contracts*. Moreover, it can be stated that *utility tokens* show innovative potential for *process optimization* in *access to a service*. Another combination also applies to the tokenization of *physical* objects and use cases associated with lifecycle tracking. In these cases, *increased transparency* is highly appreciated to provide provenance and authenticity (e.g., gold, diamonds). Tokenization introduces a desired digital scarcity for some use cases (e.g., crypto kitties⁴) and prevents replication of tokenized assets based on a *fixed* token supply. More specifically, this combination often depends on a *non-fungible* and *whole* or *singleton* token design.

Token properties and barriers for tokenization: A successful adoption of tokenization depends on various factors that may constitute a barrier for realizing a particular use case. Accordingly, it can be indicated whether common standards, operational frameworks, regulations, or technical restrictions may apply. By exploring different combinations of use cases, a difference can be drawn between improving existing business models and enabling new ones. Especially the tokenization of existing bankable assets requires a seamless integration into established financial market structures and is associated with operational *transition risks*. On the contrary, the tokenization of *physical* assets often indicates a low relevance for legacy systems. In these cases, the DLT-based platform for non-bankable assets represents a total novelty, offering a high potential for new products and services. *Utility tokens* are typically part of new innovative operating models (e.g., smart contracts, multi-party consensus) and are also characterized by moderate migration efforts. However, an additional barrier is represented through uncertainties about *regulatory and legal frameworks*. In these cases, a high correlation is identified for tokenizing existing financial asset classes (e.g., securities, currencies). While the legislation for DLT-based asset ownership is often not established yet, regulators have to refer to known legal structures. Almost all use cases with an investment purpose in the financial services sector require a new regulatory basis. A

⁴ Crypto Kitties is an Ethereum-based online game that allows users to trade, collect, and breed virtual cats as unique, indivisible, irreplaceable, and verifiable representations on the BC using Ethereum's non-fungible tokens standard ERC-721 (eips.ethereum.org).

legal framework is not necessarily required where *utility tokens* provide access to a service platform (e.g., tokenized cargo in logistics) or serve as a basis for *non-fungible collectibles* (e.g., virtual gaming items). Other use cases must meet *data privacy* requirements when tokenizing a specific object. For instance, tokenized health data is primarily processed by private permissioned DLT-frameworks that allow only selected group access to sensible data. Once many actors need to be incentivized to establish use cases, additional complexity is added to initiate and operate a DLT-based platform. For example, real estate tokenization requires a minimal viable ecosystem with various stakeholders (e.g., asset tokenizer, custodian), leading to *governance issues*. In combination with the *oracle problem*, the tokenization of *physical assets* (e.g., watches, transport containers) often relies on a consistent data connection between the on-chain and off-chain world. In particular, tangible assets in terms of unique, *non-fungible* tokens show higher relevance to this barrier than *utility* tokens.

3.4.3 Asset Tokenization Archetypes

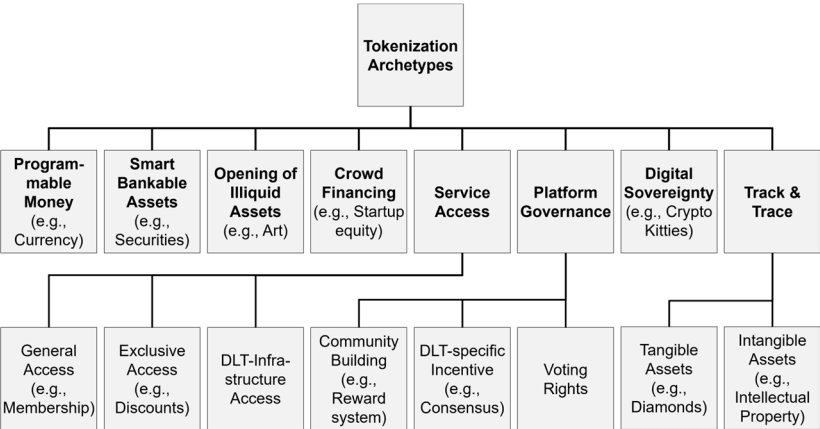


Figure 3-3: Archetypes of asset tokenization (Heines, Dick, et al., 2021, p. 9)

The empirical analysis of various use cases resulted in different patterns between the properties, drivers, and barriers. The instantiations confirmed, for example, the assumption that the same tokenized object

(e.g., watches) can be applied for multiple purposes (e.g., investing or track & trace), showing different manifestations and levels of applicability. Based on the analyzed sample of 129 firms, eight archetypical use cases of tokenization are defined in Figure 3-3. The cases represent similar combinations of sub-criteria to be understood as typical applications in existing business models, indicating the business potential of asset tokenization. As one archetype is primarily assigned to specific parameters of the assessment framework, there might be possibilities to combine archetypical use cases and extend the token's utility within a DLT system accordingly. However, several combinations between archetypes exist. For instance, use cases in supply chain finance rely on elements for *track and trace* and show similarities to the *opening of illiquid assets*. A detailed overview of the assigned sub-criteria for each archetype is also provided in Appendix D.3.

3.4.3.1 Programmable Money

The first archetype, *programmable money*, refers to use cases associated with the tokenization of currencies as a means of exchange and store of value. The archetype predominantly applies to the financial services sector and describes applications following a payment token's functionality. It covers various subtypes that range from central bank-issued digital currencies using a DLT (e.g., wholesale CBDS, retail CBDS) to privately issued stable coins (e.g., non-regulated entities). By offering price stability, tokens can be pegged to an official legal tender (e.g., tether USD), commodity (e.g., gold), or another cryptocurrency. Compared to existing payment infrastructures (e.g., central clearing and settlement), tokens used as programmable money enable instant and automated post-processing through smart contracts. Accordingly, it is possible to trigger events and services on decentralized platforms without mediation through a third party (e.g., DVP). The difficulties lie in complex governance mechanisms for a group of stakeholders (e.g., central and commercial banks), increased migration risks, and various legal frameworks that need to be considered for successful adoption.

3.4.3.2 Smart Bankable Assets

The second archetype, *smart bankable assets*, is also driven by process optimization within existing financial markets infrastructures. On one side, the tokenization of tradable financial assets or securities (e.g., stocks, bonds, derivatives) improves post-trade processing by reducing centralized administration efforts for clearing, settlement, and associated servicing activities between direct market participants (e.g., custodian bank, central securities depository). On the other, smart bankable assets extend the functionalities further to automate additional processes during the trade lifecycle and reduce costs across all stakeholders (e.g., corporate actions). By programming a financial contract logic into the token, events such as cash dividends or reporting activities can be automated once a specific condition of the smart contract is met. Even voting rights for shareholder meetings can be automatically weighted and conducted according to the investor's number of shares. In addition, the usage of tradable and fungible tokens further increases transparency for regulators and lowers the investment barriers based on increased liquidity and fractional ownership. Besides transition risks for integration into existing legacy systems, further challenges can occur by governing the various market participants and consistently monitoring the legal and regulatory requirements.

3.4.3.3 Opening of Illiquid Assets

Besides established markets structures for known financial assets, the third archetype, *opening of illiquid assets*, describes the usage of tokens for investment purposes by representing unique or fungible proxies for something physical of value. The archetype primarily facilitates the digitalization process and trading through standardized requirements for the transfer and management of asset ownership (e.g., ERC-20 token standard). Compared to centralized platforms, costs can be reduced to successfully operate secondary market infrastructures for niche-investment products that were previously not economically viable (e.g., tokenized real estate). Moreover, the issuance, transfer, and storage of tokens add additional usability for market participants by design.

Market friction decreases when fractionalized investment denominations of tokenized classic cars or real estate can be small. Trading low amounts profitably lead to the democratization of markets and increased financial inclusion. However, operational risks must be considered. In addition to external data sources, a diverse ecosystem of different actors is required that meets legal and regulatory requirements.

3.4.3.4 Crowd Financing

According to democratization and facilitated market access, *crowd financing* represents a more specialized type of financial inclusion for both borrowers and lenders. The tokenization of private equity and debt emerged early in so-called ICOs to fund a BC project or venture using cryptocurrencies. Compared to common financing forms (e.g., Initial public offering), the transactions are characterized by reduced cost through simplified issuance of debt in the form of tokens, disintermediation of external service providers, and facilitated pooling of funds through DLT-based platforms. While raising small funds from a broad investor base has not been economically viable before (e.g., due to costly intermediaries), tokens enable real-time crowd investments with flexible fractionalization of funds that may cover almost everything from private projects to venture capital. In addition to facilitating processes for issuers, investors benefit from increased liquidity and non-stop tradability in unregulated markets. On the contrary, legal frameworks must be considered, as market actors can become subject to regulation. While crowd financing cases are often community-driven, designing non-monetary incentive mechanisms among required stakeholders is challenging to reach scalability and adoption.

3.4.3.5 Service Access

Many use cases have been identified that utilize tokens as an instrument for acquiring rights to a specific service. Accordingly, the fifth archetype, *service access*, covers applications among various industries providing an alternative infrastructure to manage access control, utility

rights, or contractual rights between a service provider and token holder (cf. user, bearer). In particular, licenses, memberships, or loyalty points can be tokenized to allow effective processing and secure handling on DLT-based platforms. Once the desired functionality is implemented, the token grants service access according to the conditions met in the predefined smart contract. The owner of the token is granted, for example, unrestricted access to services, exclusive benefits and discounts, or DLT-specific infrastructure permissions. The token can be designed to be fungible and non-fungible with unique private or broader public functionality. The services and functionalities offered by the token depend on the provider. As long as no specific contractual obligations with the counterparty are required, regulation can be neglected for these kinds of use cases. However, as the degree of integration varies, tokenization of service access might pose challenges in ensuring a secure connection with external data sources (cf. oracles) and a required minimum viable ecosystem to be established (e.g., governance issues).

3.4.3.6 Platform Governance

Following the sixth archetype, *platform governance* describes a broader area of tokenization cases to incentivize users within a system. As a means for coordination and cooperation, tokens are typically applied in DLT protocols to reward users for completing tasks or fulfilling a particular behavior. For example, the Bitcoin protocol distributes mining rewards for transaction validation across participating nodes (i.e., miners) using computational resources successfully. Besides the DLT-specific incentive mechanism for consensus, tokens might also be issued, valued, and redeemed in their own right to facilitate community building or voting. More specifically, users are not solely incentivized by a future monetary reward for receiving a token but may achieve higher status and influence. Thus, the number of governance tokens earned represents social value by governing voting power and creating community sense. On the contrary, the value is often tied to the platform's overall success and a critical number of network effects. Following this, the token should be fungible and transferable. Compared to conventional

solutions, such use cases are promised to achieve democratization, process optimization, and reduction of intermediaries. Barriers relate to data privacy concerns (e.g., pseudonymity vs. anonymity) and complexity in designing the incentive mechanisms (e.g., reward distribution).

3.4.3.7 Digital Sovereignty

As one of the main features of DLT, the seventh archetype, *digital sovereignty*, is introduced to enable verifiable digital scarcity. The archetype covers applications based on unique and non-interchangeable representations of data to provide proof of ownership for the token holder. Following a non-fungible token design, the reference on a shared ledger proves authenticity and cannot be manipulated by a single party. Use cases range from digital content in terms of pictures, videos, or audio to other digital records or identities associated with physical counterparts. By extending functionality on decentralized gaming platforms, a token could, for instance, represent a virtual in-game asset to be explicitly owned by the user (e.g., Crypto Kitties). A single game provider cannot alter the ownership, leading to more democratization and control for the individual. Such assets are often designed to be transferable and traded on marketplaces but may also be tied to a specific owner. For the tokenization of sensible data, requirements for data privacy must be met. Physical assets should be linked to their unique token to ensure authenticity and ownership beyond DLT-systems.

3.4.3.8 Track and Trace

The last archetype refers to use cases associated with *track and trace*, where tokenization is applied to establish a consistent audit trail and tamper-proof-record of ownership across various stakeholders. Firms utilize tokens to increase transparency along the lifecycle by representing tangible or intangible assets. Especially within the transport sector and in supply chain management, logistic transactions can be monitored by handing over a product from one supplier to another and storing the transfer of ownership on a shared ledger in real-time. For

instance, a container token transaction streamlines information with all supply chain participants while preserving availability and data integrity through the DLT-based platform. It has been identified that consumer goods often follow fungible properties. In contrast, valuable items such as diamonds are represented, most notably, in the form of non-fungible tokens based on unique physical characteristics. Besides transitions risk and additional efforts for integration into existing systems, external data has to be considered to provide authenticity of the physical asset. Especially for provenance tracking, various automatic identifier and data capture technologies (e.g., QR codes, RFID sensors) are required.

3.5 Chapter Summary

The previous chapter focused on the first artifact of this thesis and introduced an assessment framework for ideation that illustrates how firms can apply asset tokenization to innovate their businesses. Based on a literature review and expert interviews, 12 dimensions with 44 evaluation criteria in the context of different token properties, drivers, and adoption barriers were derived. Thus, the criteria represent a basis for assessing the business potential of use cases in a given scenario. According to an example of a tokenized classic car, it could be shown that the artifact allows practitioners to assign token manifestations, strengths, and weaknesses to a specific use case and compare viable solutions for different tokenized objects.

In addition to conceptualizing innovative products and services, the artifact was also applied in an empirical analysis based on a sample of 129 companies associated with tokenization. Recurring patterns between token properties, drivers, and barriers of the various instantiations led to eight asset tokenization archetypes as frequent combinations of similar sub-criteria such as *programmable money*, *smart bankable assets*, *opening of illiquid assets*, *crowd financing*, *services access*, *platform governance*, *digital sovereignty*, and *track & trace*. The archetypes reduce complexity in this highly dynamic area and demonstrate that the same tokenized object (e.g., watch) could be applied for multiple purposes (e.g., opening of illiquid assets or track & trace).

4 A Conceptual Model for Asset Tokenization

Tokenization provides a new paradigm for issuing, transferring, and storing tokenized assets on DLT-based platforms to reduce drawbacks of intermediaries, such as single points of failure or lagging processing times. Without requiring a central instance for managing asset ownership, the concept can significantly transform existing value chains in the financial services sector. So far, a blueprint is missing that indicates how to establish and set up asset tokenization as a new kind of financial market infrastructure. Based on practical requirements (Section 2.6.1), the chapter introduces the second artifact and addresses a conceptual model for designing a holistic value architecture for asset tokenization. First, the foundational approaches relevant to the model are presented. Preliminary work on DLT-based platforms and architectures further complements the basic conceptualization. Based on primary data, the second section introduces the case studies to develop the artifact. The third section outlines the modeling approach before presenting the results and model descriptions in the fourth section. Then, the applicability of the overall model is demonstrated in two single case studies. Finally, the chapter concludes with the results and a final artifact evaluation.

4.1 State of the Art

The section presents the state of the art in terms of relevant elements for the conceptualization of asset tokenization in the financial services sector. First, foundational modeling approaches of the artifact are introduced before related work within the BC and DLT domain is discussed.

4.1.1 Foundational Modeling Approaches

Relevant models and frameworks are presented that serve as a foundation for developing the second artifact. Accordingly, different business model frameworks, layers of business engineering, and the concept of architecture models are addressed and considered.

Business Model Frameworks: Often following a conceptual nature, business model frameworks allow the description of a firm by illustrating specific business model components (Section 2.4.2) that visualize a business's current or future target state. Depending on its scope, a framework can cover the main parts of a business model (e.g., value proposition, value creation, value capture) to systematically structure a business idea, its implementation, and operationalization in the form of a product or service (Osterwalder et al., 2005). Applied as management tools, they provide strategic guidance to understand one's own business, identify new business opportunities, and evaluate potential market entry (Stähler, 2002). The development of such concepts is called business model design, typically following non-formal modeling approaches and general modeling principles. For instance, Weill & Vitale (2001) use textual and graphical elements to support a transition towards e-business models. The framework covers illustrations of stakeholders, their relationships, and the respective financial, physical, and information flows. However, formalized approaches also exist. For example, the business model canvas by Osterwalder & Pigneur (2010) provides so-called *building blocks* that are initially based on a DSR artifact in terms of an ontology. It represents a formal definition of elements, relations, and semantics instantiated into a visual chart to describe the value proposition, infrastructure, customers, and financials of a business, to name a few (Osterwalder, 2004).

Various frameworks are used in practice for business model design, often providing an abstract representation and approximation of reality. Therefore, the required level of granularity depends on the objectives, target audience, and scope. For example, developing a business strategy for c-level managers can be conducted on a higher level of abstraction, whereas introducing new operational processes for a product requires a more detailed conceptualization for project managers to evaluate new suppliers or integrate business processes. Following the business model concept by Stähler (2002), a framework's focus may lie on the *value proposition*, *value architecture*, or *profit equation*. For the dissertation's second artifact, a value architecture is appreciated that addresses how value is created and how products and services are

delivered to the customer within a particular configuration. Frameworks for developing such architectures include descriptions of the various stages (cf. value chain) and the numerous actors involved in value creation (cf. value network) (Bouwman et al., 2005; Mahadevan, 2000; Timmers, 1998). The concept of illustrating the activities of a firm based on a process view was first described by Porter (1985). A value architecture often relies on this approach to represent tasks in terms of *business processes* that are interrelated and distinguishable (e.g., primary activities, support activities). While such end-to-end processes usually involve more than one actor, a *value network* illustrates shared value creation beyond company borders. Accordingly, additional participants (e.g., suppliers, providers) are identified to deliver value to the customer. However, a more comprehensive approach is desirable to capture the various elements for designing asset tokenization. Accordingly, more detailed blueprints with their characteristics are discussed further.

Business Engineering: The introduction of disruptive technologies and IT innovations enable new business solutions. Established companies must consistently reevaluate their existing business models and adapt quickly to changing market environments. As a result, new services, products, and processes emerge that require new forms of management to transform the organization or even entire value chains (Otto et al., 2015). To successfully address the increased complexity of digitalization, a holistic approach to enterprise modeling is appreciated that involves far more than a generic view of a firm's business model (Winter, 2008). While most practices focus exclusively on strategic management, organizational design, or information technology-oriented aspects, Business Engineering (BE) represents a method and model-driven approach to systematically conceptualize the transformation of a company (Österle & Winter, 2003). Following the *St. Galler BE approach* by Österle & Winter (2003), a step-wise redesign involves various concepts (e.g., core business meta-model) and different techniques (e.g., process modularization) that lead to distinct design deliverables (e.g., service map). The transformation is conducted in sequential order across a firm's *strategy, processes, systems layer* and covers *cultural*

aspects. Figure 4-1 presents the generic BE model and illustrates the integrated view to support a comprehensive transformation process.

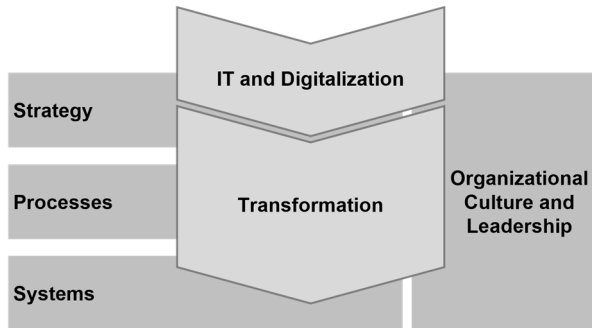


Figure 4-1: Business Engineering (Österle & Winter, 2003, p. 12)

Only selected aspects of the layers above are addressed as a foundation for the second artifact. On this basis, the *BE strategy layer* primarily defines the roles and activities of the business network. The conceptual model for assets tokenization could illustrate the relevant participants in such networks and highlight the need for collaboration and coordination between companies. The provision of token-based products and services is elaborated based on a process architecture. The *BE process layer* also provides an overview of tasks a business partner performs based on their network role. Accordingly, dependencies between tasks are highlighted and divided into main and sub-processes. The *BE systems layer* represents the technical architecture for developing DLT-based systems that use tokens to improve the transfer of asset ownership. This element can be further subdivided into granular layers (e.g., application architecture, infrastructure) to ensure the operation and integration of the technical components. However, internal resistance must also be overcome. Therefore, corporate culture is considered and elaborated separately as part of the third artifact (Section 5.4). Finally, it has to be taken into account that other BE approaches may rely on more detailed overviews. For instance, Winter (2008) proposes an alignment layer between processes and systems. In this study, BE extends the possibilities of business model frameworks and provides an appropriate foundation for the initial model design.

Architecture Models: In addition to transformational approaches and conceptual business modeling, companies must consistently align strategic changes with their existing processes and infrastructures (Jung, 2006). Especially, the dependency on IT systems requires increasing flexibility to adapt and respond more quickly to new market needs (Gharajedaghi, 2011). By relying on a so-called monolithic system with rigid components, business process redesign can lead to redundancies and complexity for the underlying IT infrastructure (Versteeg & Bouwman, 2004). A blueprint is needed that provides a generic overview of both business and IT and more detailed elements that further address a reusable design of company-specific information systems and processes. Such blueprints are often based on so-called *architecture models* that follow a modular approach. Thus, they allow a system to be designed according to its architectural components and relationships (Alt, 2008). Analogous to the construction of buildings, the architecture provides a static view and represents a known reference to conceptualize organizational IS. Using IS architectures, companies can illustrate more granular levels of an IT-related artifact (e.g., application system, software components) and reduce complexity for development based on predefined building blocks and standardized combinations of reusable design elements (Winter & Fischer, 2006).

Where a conceptualization in terms of architectures originated primarily in the IS domain (e.g., software architectures), the strategic importance of such abstractions has also been recognized for other purposes. Accordingly, the concept can be extended to describe, for example, business-related artifacts that provide a template solution for developing additional organizational structures (e.g., business processes). Such architectural elements may differ in scope and specificity for a particular domain to be separated into layers, for example, business, information, and technology (Versteeg & Bouwman, 2004). In this sense, so-called *business architectures* provide a blueprint to align strategic objectives and operational activities of the company, bridging the gap between the business model and its successful execution (Business Architecture Guild, 2019). Following the definition of the *Federation of Enterprise Architecture Professionals*, a business architecture consists of “holistic,

multidimensional business views of capabilities, end-to-end value delivery, information and organizational structure [...] and the relationships among these business views and strategies, products, policies, initiatives, and stakeholders" (Ulrich & Newcomb, 2010, p. 4). Additional core elements further address a firm's business process and governance (Ghahramany Dehbokry & Chew, 2014). As a result, the dissertation's second artifact partially builds on such interdisciplinary aspects to define and specify the value creation of asset tokenization. In particular, the proposed conceptual model allows the design of relevant processes and structures, identifies strengths and opportunities for the firm, and enables the illustration of such business models in more detail.

However, business architectures can also be utilized as a vital component of a broader *enterprise architecture* that represents a blueprint with more granular views for the organization as a whole, covering various domains. In addition to business views, it typically includes process, integration, software, and technology architectures depicted as layers to define, illustrate, and design the structure and interactions of components that range from strategy to operations (Winter & Fischer, 2006). Several industry standards and established frameworks for designing, planning, and implementing enterprise architectures exist, such as the *Zachman Framework* or the *Open Group Architecture Framework* (TOGAF, 2021; Zachman, 1987). Where enterprise architectures rely on a comprehensive set of principles, methods, and models, the foundational elements of the second artifact only cover selected aspects, such as sub-layers and static components (e.g., network layer, roles). The conceptual model for asset tokenization combines business and technical views. However, a formalized and systematic reference modeling approach is neglected in this study as only basic architectural logic applies (e.g., top-down approach, domain-specific overviews).

4.1.2 DLT-based Architecture Frameworks

While the foundational modeling approaches provide a frame for developing the second artifact, a review of existing frameworks and architectures within the broader BC and DLT domain is further conducted. The

goal is to evaluate the current body of knowledge and address elements for establishing token-based platforms or asset tokenization business models. Only a representative sample of articles is discussed to identify prevailing research streams in the following. However, a systematic review of applied elements for the solution artifact is later conducted for the initial rigor cycle as part of the DSR process (Section 4.3.2.).

Following the phenomenon of asset tokenization, the initial research gap has indicated a missing understanding for conceptualizing such novel business models (Section 2.6). Therefore, the focus lies on relevant elements to bridge this gap and should also cover general BC and DLT based infrastructures and decentralized platforms. As shown in Table 4-1, previous research associated with conceptualizations of different DLTs, their applications, use cases, and related areas can be divided into three major research streams: (1) *classificatory frameworks*, (2) *technical architectures*, and (3) *conceptual frameworks*. Whether it is a categorization to structure ideas, a reference technology stack for building applications, or a framework for modeling the cryptocurrency ecosystem, the focus significantly varies depending on the research objective, scope, and methodology chosen.

Research Stream	Classificatory Frameworks	Technical Architectures	Conceptual Frameworks
Exemplary RQ	<i>Which DLT-based business models can be observed and how can they be characterized?</i>	<i>How is an architecture for a blockchain-based trade certificate system designed?</i>	<i>How do cross-border payment platforms operate?</i>
Selected References	Glaser & Bezenberger (2015); Xu et al. (2017); Rückeshäuser (2017); Labazova et al. (2018); Ballandies et al. (2021); Heines & Gürpınar (2021);	de Kruijff & Weigand (2017); Che et al. (2019); Abreu et al. (2020); Mazzei et al. (2020); Mohsen et al. (2020); Latif et al. (2021);	Glaser (2017); Notheisen et al. (2017); Giraldo (2018); Rauchs et al. (2018); Seebacher & Maleshkova (2018); Labazova (2019);

Table 4-1: Research streams on DLT and BC-based conceptualizations

The first research stream on *classificatory frameworks* deals with approaches to distinguish, describe, and organize knowledge based on empirical data (i.e., taxonomies) or constructs anchored in existing theories (i.e., typologies). These contributions either address economic relationships, for instance, a comparison of DLT-based business applications (e.g., Heines & Guerpinar, 2021; Rückeshäuser, 2017) or operational aspects, such as the classification of DLT-systems (e.g., Balandies et al., 2021; Glaser & Bezzenberger, 2015). Secondly, research on *technical architectures* provides new insights into the application design by highlighting references implementations of a specific use case. Mainly empirically driven, they illustrate respective soft- and hardware layers, for example, in the area of IoT (e.g., Latif et al., 2021; Mazzei et al., 2020) or enable a shared understanding and terminology based on ontologies (e.g., de Kruijff & Weigand, 2017; Mohsen et al., 2020). The third research stream on *conceptual frameworks* builds upon generic approaches for modeling the socio-technical nature of BC and DLT by combining both a business and technological perspective. Existing research investigates, for example, the integrated elements of decentralized platforms, such as the interplay between application and infrastructure (e.g., Glaser, 2017; Rauchs et al., 2018) or identifies pivotal elements of its ecosystem (e.g., Notheisen et al., 2017; Riasanow et al., 2018). Besides DSR based artifacts (Labazova, 2019), more formalized approaches are also applied (Seebacher & Maleshkova, 2018).

While prior work contributes to a diverse field of different conceptualizations, a comprehensive blueprint for designing token-based platforms or asset tokenization-business models is still missing. However, the three research streams highlight selected elements to conceptualize asset tokenization in the financial services sector. Therefore, some of these frameworks and architectures are discussed below.

Classificatory frameworks: The growing number of classifications highlights the importance of taxonomies and typologies as a common instrument for organizing knowledge within the BC and DLT domain. According to taxonomies, various contributions follow a bottom-up approach and present empirically-derived categories and characteristics

typically addressing technical or business-related research objectives. Some early work on classifying decentralized consensus systems is presented by Glaser & Bezenberger (2015). To lever new opportunities for application areas beyond cryptocurrencies, six dimensions and sixteen characteristics are introduced to provide a helpful tool for practitioners and researchers for description and analysis. Xu et al. (2017) specify the technical perspective and compare different systems according to relevant design decisions, options, and architectural considerations to facilitate the selection of an appropriate BC. The taxonomy consists of three layers (i.e., decentralization, storage and computation, BC configuration) and builds upon secondary (e.g., technical forums, academic literature) and primary data (e.g., prototypes, existing products). Figure 4-2 shows an excerpt of the classification based on a selection of different options. By choosing a particular BC with specific properties, the developer can anticipate system behavior and evaluate the impact on the software architecture.

Design Decision	Option	Fundamental properties	Impact		
			Cost efficiency	Performance	Flexibility
Blockchain scope	Public blockchain	⊕⊕⊕	⊕	⊕	⊕
	Consortium/community blockchain	⊕⊕	⊕⊕	⊕⊕	⊕⊕
	Private blockchain	⊕	⊕⊕⊕	⊕⊕⊕	⊕⊕⊕
Data structure	Blockchain	⊕⊕⊕	⊕	⊕	⊕
	GHOST	⊕⊕	⊕⊕	⊕⊕	⊕
	BlockDAG	⊕	⊕⊕⊕	⊕⊕⊕	⊕⊕⊕
	Segregated witness	⊕⊕⊕	⊕⊕	⊕	⊕

⊕: Less favourable, ⊕⊕: Neutral, ⊕⊕⊕: More favorable

Figure 4-2: Excerpt from blockchain-related design decisions regarding blockchain configurations by Xu et al. (2017, p. 249)

Ballandies et al. (2021) also address the difficulties in architecting DLT-based systems in terms of various design choices and their impact on system requirements. As a result, a taxonomy of DLT systems is developed and applied to 50 existing DLTs to assess the implications of individual design features on performance and derive guidelines for designing viable applications. Labazova et al. (2018) extend these approaches by combining technical and application knowledge within a taxonomy of eight technical dimensions (e.g., consensus mechanism,

reading access, data exchange type) and six application areas consisting of twenty-five cases (e.g., cryptocurrencies, enterprise smart contracts). Besides specifying technical features and identifying trade-offs in DLT and BC-based systems, other scholars use classifications to structure the business potential of this disruptive technology. Based on existing theories, typologies provide grounded criteria to distinguish business models (Rückeshäuser, 2017) or describe application areas from a managerial point of view (Heines & Guerpinar, 2021). Regarding the conceptualization of asset tokenization, it is useful to rely on such classifications and apply selected elements to increase the applicability, consistency, and completeness of the second artifact.

Technical Architectures: DLT has gained increasing attention for many other use cases beyond cryptocurrencies by overcoming drawbacks of centralized IS (e.g., non-transparent business processes, information asymmetries). In addition to theory-driven IS research, many contributions aim at practical implementation to create new knowledge in software engineering and computer science (Rossi et al., 2019). Accordingly, a focus lies on the functional and technical design of a specific DLT-based application that typically results in a software artifact describing an exemplary architecture for development. These artifacts can rely on a formalized modeling language with ontologies that enable a technical understanding through representation, definition, and description of the domain. For instance, De Kruijff & Weigand (2017) take an ontological approach to help organizations apply smart contract features across three BC levels (i.e., logical data, logical information, and essential information). Also, Mohsen et al. (2020) specify a solution design of a BC-based prototype for collaboration in companies in terms of a worldwide ontology ledger. As a result, the artifacts illustrate concepts, design principles, appropriate platform technologies, and platform architectures. In this context, Abreu et al. (2020) present a reference architecture with five essential layers and respective components (Figure 4-3) to identify challenges in implementing an innovative application for student degree certificates based on the Ethereum BC.

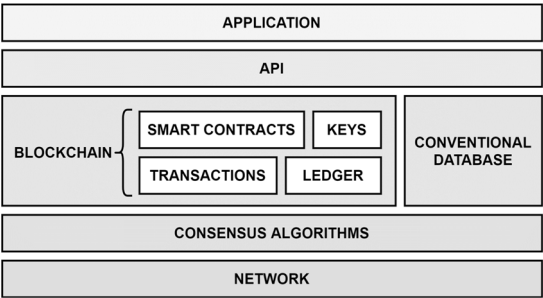


Figure 4-3: Architecture for BC-certification (Abreu et al., 2020, p. 154)

However, various contributions exist for many DLT use cases with an extended focus on the development process, referring to class diagrams, UML models, or other design documents (Che et al., 2019). By combining both soft- and hardware, insight into the application design of DLT-based applications and IoT devices can be further identified as a growing application area within this research stream (Latif et al., 2021; Mazzei et al., 2020). As a result of this review, it can be stated that an interdisciplinary perspective is required to provide a holistic blueprint for designing the value architecture for asset tokenization. Accordingly, previous work may serve as a sound foundation considering the technical components for platform design.

Conceptual frameworks: The third research stream typically includes non-formal models and aims to establish a socio-technical understanding by combining various perspectives on DLT systems and their application areas. Compared to formalized modeling approaches, such conceptualizations are generic and allow for investigation, comparison, and analysis based on modular elements and abstract layers. They cover multiple application domains and can be used in practice in various ways. Among the few multidisciplinary contributions, Glaser (2017) develops, for example, a conceptual framework of BC-based ecosystems in the context of digital economies. The proposed frame of reference builds upon an ontology and presents two layers with components (e.g., application layer, fabric layer) to assess novel business models and derive potential implications on existing markets. Multifaceted considerations (e.g., infrastructure, governance, interaction) are also addressed

in the framework by Labazova (2019, p. 5). As a result, factors in the four categories of *innovation*, *design*, *inter-organizational integration*, and *implementation environment* are introduced to manage projects related to BC and DLT successfully. In general, conceptual frameworks can serve as an analytical tool used to make conceptual distinctions (e.g., Rauchs et al., 2018) or structure a concept of something real (e.g., Giraldo, 2018) in a simplified manner. A comprehensive framework for designing the elements of BC-based markets outcomes is described by Noteisen et al. (2017). As shown in Figure 4-4, multiple layers with respective elements are considered to conceptualize platforms and enable the construction of such ecosystems on micro and macro levels.

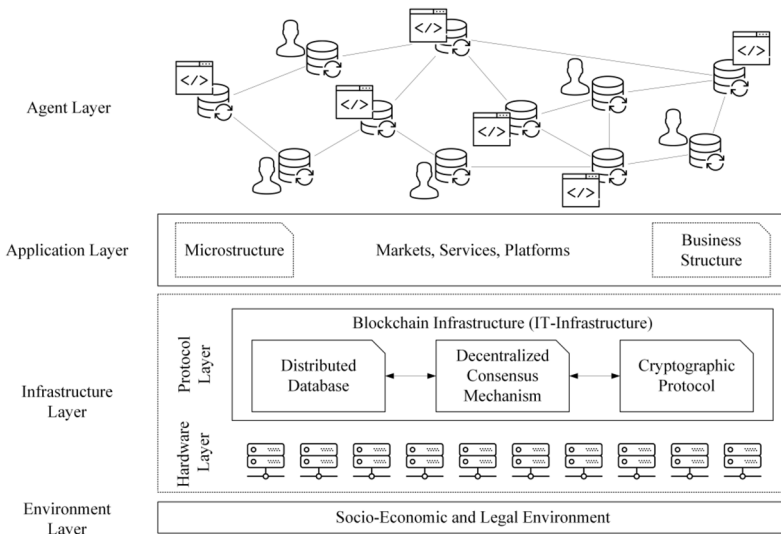


Figure 4-4: Market Engineering Framework (Notheisen et al., 2017, p. 1073).

Although the framework applies to various use cases, it is appreciated to address additional and more detailed elements for developing asset tokenization business models (e.g., governance, processes, technical architecture). Previous approaches can be extended to illustrate the elements for the second artifact of this dissertation. While some aspects are still missing, this study also considers selected contributions, such as the generic BC-based ecosystem roles (Riasanow et al., 2018) or DLT network models (Seebacher & Maleshkova, 2018).

4.1.3 Discussion on Related Approaches

Prior research revealed no comprehensive blueprint to conceptualize asset tokenization. However, the review on foundational modeling approaches and selected DLT architecture frameworks provided insights to be considered in developing the conceptual model and potential elements that might address the practical requirements for the financial services sector. The related approaches and their relevance for the second artifact of this dissertation are further summarized and discussed.

Analogous to business model design frameworks, the dissertation draws on generic modeling principles and non-formal approaches to develop an artifact as a tool for illustrating business models that are associated with asset tokenization. The conceptual model primarily guides strategists in the financial service industry and practitioners from IT, business architecture, and technical consulting. Especially, the approach of highlighting value creation within a range of possible configurations is highly appreciated by organizations. Therefore, a comprehensive blueprint should allow the instantiation and customization of different tokenization scenarios regarding predefined dimensions and parameters. Besides an abstract representation of relevant elements, core aspects of business model frameworks such as the conceptualization of value architectures, value chains, or value networks are further considered. As a result, inter-organizational structures and basic end-to-end processes associated with tokenization are illustrated and identified to complement and establish an understanding of this phenomenon on a strategic level.

The St. Galler BE Model by Österle & Winter (2003) assumes that most changes in a company's business model emerge from new technological innovations. For this reason, it provides a suitable foundation for developing a model that guides companies through a repositioning driven by DLT and the disruptive potential of asset tokenization. As a result, the modeling of the artifact is based on BE's holistic view of transformation and its approach to business model redesign. Through BE's integrated understanding of a firm's strategy-, processes-, and systems

layer, the artifact draws on selected elements to overcome complex challenges in the introduction of token-based business models as a whole (e.g., business network, participants, service map, and IT). By applying basic design principles, such as the differentiation of main and sub-processes, the applicability of the artifact can be further increased. While BE also represents a method-driven approach for systematically supporting the transformation of organizations, the artifact primarily aims at an initial descriptive blueprint for this novel phenomenon.

For the second artifact of this dissertation, selected principles on architectural models were also considered to construct and represent the complex formal and informal structures of asset tokenization. Here, an architectural perspective is applied, for example, to create a shared understanding between different business functions such as management and IT. In particular, the conceptual model illustrates distinct elements of DLT and related tokenization business activities. In addition, the artifact enables the identification of critical resources that range from strategy to operations. (e.g., business architecture, application architecture). A focus lies on technical architectures for asset tokenization, but existing approaches from the enterprise architecture domain are only partially covered. Developing a model in terms of a formalized reference architecture may go beyond this work's objective.

In addition to basic modeling approaches that provide a foundation for generic artifact development, DLT-based architectural frameworks also provide pivotal elements for an initial model design and serve as a suitable terminological and conceptual reference. Although research on asset tokenization remains scarce, theoretical groundwork is found in existing BC and DLT conceptualizations and related IT artifacts as part of the three major research streams. Classificatory frameworks support the model's applicability, consistency, and completeness. Specific categories and criteria are presented in the model as they have technical or managerial implications for design decisions associated with asset tokenization. Furthermore, the artifact draws on existing technical architectures for BC and DLT applications to illustrate the strategic and operational platform design. Finally, conceptual frameworks are applied

in the first place to provide a descriptive basis. As a result, such approaches are consistently extended beyond their original elements to meet the practical requirements within the DSR cycles and establish a first foundational blueprint for the financial services sector.

4.2 Case Studies

The conceptual model additionally builds on industry insights to address the relevant elements for conceptualizing asset tokenization in practice. Specifically, six case studies have been conducted to identify how innovative firms establish businesses around asset tokenization (Rowley, 2002; Yin, 2013). Based on a structured presentation of the real-world data, this chapter first presents the selection criteria for the chosen cases. The second section introduces the six case study summaries and describes the selected companies in more detail. Finally, overall findings from this study are discussed to conclude practical insights from this phenomenon. This empirical approach is part of a broader DSR process, also specified in the respective design cycle in Section 4.3.3. The multiple case study was completed in February 2022 and does not account for changes in company profiles after that date.

4.2.1 Case Study Selection

Empirical data based on multiple case studies is appreciated to ensure the real-world fidelity of the resulting artifact and establish more robust insights compared to single case studies (Yin, 2013). As a result, six companies are considered to sufficiently meet the level of generalizability from multiple cases (Rowley, 2002). A descriptive analysis depends on an appropriate source of knowledge, where the selection of cases typically represents a challenge in case study research. For example, Dubé & Paré (2003) state that the choice for a set of cases should be either driven by the prediction of similar (cf. literal replication logic) or contrasting results (cf. theoretical replication logic). Also, Eisenhardt & Graebner (2007) refer to a sampling approach of heterogeneous types to gather contrasting data. While existing literature offers a wide range of case selection techniques, Seawright & Gerring (2008)

suggest a pragmatic approach to purposefully select cases based on predefined criteria. In the following, five criteria are presented that specify the data collection and analysis:

- The cases should feature companies that utilize the tokenization concept as a central part of their operations or business model (e.g., platform provider, token issuance services).
- The selected cases studies should preferably cover different asset tokenization archetypes (Section 3.4.3, pp. 86) associated with the financial services sector to sufficiently represent the current state of the tokenization ecosystem.
- The cases should differ based on their organizational characteristics to capture different aspects and types of asset tokenization business models. For example, the considerations may include the market coverage, target group, industry affiliation, company size, and structure.
- The case studies should cover companies that have already reached certain milestones or overcome challenges in various areas (e.g., technical, legal), with company representatives having at least two years of tokenization project experience.
- Each case and participating company should support the data collection and analysis to provide comprehensive insights for the research project. Participants should be willing to share experiences even on sensitive topics, with the possibility to have the case study anonymized and published.

Six case studies with seven companies were selected, focusing on operational tokenization platforms or projects with a high maturity level. These businesses were related to the financial services sector (e.g., financial services, service providers, and fintechs) and located in the D-A-CH region. All participants were either CC Ecosystems members or were contacted as part of its broader network. According to the artifact's

modeling approach, a detailed description of data collection and analysis of the chosen use cases is also elaborated in Section 4.3.3.

4.2.2 Case Study Summaries

The case studies are presented and summarized in the following sections. Besides secondary data (e.g., company documents), the data collection was primarily conducted using semi-structured interviews with company representatives to validate and exchange information. The first fintech (1) offers a software-as-a-service for tokenizing assets and shares to be represented as legal entities in Liechtenstein. The second case (2) describes a Swiss technology platform for security tokens to increase the liquidity of bonds and private debt in financial market infrastructures. Another case study is based on a collaborative approach (3), where a Swiss cantonal bank and a fintech create a digital asset ecosystem to tokenize securities of small and medium-sized enterprises (SMEs). The fourth case (4) describes a German fintech that offers solutions and API services based on crypto and digital assets for institutional investors and financial service providers. The following case of a major Swiss Exchange (5) provides insights into a fully regulated digital market infrastructure for tokenized bankable assets (e.g., stocks, bonds). The last case (6) illustrates the integration of digital assets into the existing infrastructure of a private bank by establishing a platform for regulated issuance, trade, and custody services.

The summaries are based on a generic company overview, the solution design, and an outlook for each case. Firstly, the company overview covers basic information about the organization (e.g., business area, number of employees). Then, the solution design outlines the scope and objectives, specifying the business model, product, service, or platform. Lastly, the outlook deals with the company's opportunities and further developments, describing notable findings. It must be taken into account that an overview of each case study and its role in artifact construction and evaluation is separately depicted in Section 4.3.3. Thus, the following case study summaries serve as a first introduction to capture the overall situation of a particular case.

4.2.2.1 *Amazing Blocks*

The *Amazing Blocks AG* is a Liechtenstein-based fintech with around ten employees specializing in digital asset services and consulting in various industries. Founded in 2020, the company initially launched a software-as-a-service for institutional clients to tokenize shares of legal entities based on equity tokens regulated under the Liechtenstein Token Act⁵. The goal is to standardize processes to facilitate administration, cut costs, and reduce lead times. Tokenized shares for new investors are generated and transferred with the software in a few clicks. In addition to the platform, the company relies on a broad network of partners to meet relevant technical and legal requirements.

Other use cases enable facilitated fundraising or improve shareholding structures (e.g., employee stock ownership). Among other things, tokens can also serve as a legal wrapper (cf. special purpose vehicle) to tokenize other assets legally (e.g., securities, real estate, trademarks). The company utilizes different token types (e.g., security tokens, stable coins) depending on the application area. Tokenized assets can be exchanged and transferred in seconds. Another benefit lies in increased transparency for both investors and shareholders. The provision of the software includes the development, distribution, and operation of the necessary technical systems. As a key technical component of the platform, a public permissionless BC is mainly used. The technology saves costs and time while fulfilling the security standards. Customers can further integrate the services into their businesses via APIs.

Amazing Blocks looks forward to creating a tokenization standard in line with legal requirements. Compliance with existing frameworks is considered a top priority for institutional clients and companies. Accordingly, the offerings of the fintech are based on the specifications of the Liechtenstein Token Act to comply with practical requirements. As one of the first companies, the company already tokenized its shares, locking its equity based on the Ethereum BC in the founding process.

⁵ Legal framework that regulates the use of blockchain technology in Liechtenstein (GVTG, 2019).

4.2.2.2 *StokenX*

The fintech *StokenX* is based in Switzerland and was founded in 2021 as a spin-off of Alpine Tech, which pioneered early in crypto mining. As a growing startup, the company employs up to ten people and has developed a technology platform for regulated financial institutions to trade security tokens seamlessly on internal marketplaces. Investors typically pay a substantial fee or discount to brokers to trade less liquid assets. The solution addresses these pain points in financial market structures (e.g., bonds and private debt market) and provides liquidity without friction through its fully compliant system built around BC and DLT. In addition, *StokenX* is consistently partnering with regulated institutions to create a global liquidity pool for security tokens.

At its core, the fintech provides an open-source platform in a secured, fully-regulated environment to be agnostic to banking systems or custody providers. It is specifically designed for various users in the financial services industry (e.g., asset managers, fund managers, brokers, and family offices). The white-label solution is then embedded into the infrastructure of regulated financial institutions, where users can buy and sell security tokens on internal marketplaces. In addition, the institution can manage the platform (e.g., adding security tokens) and rely on a global liquidity pool using *StokenX Markets* or automated market makers. Although the proof-of-concept is based on R3 Corda, its open architecture is also agnostic to other BC and DLTs.

StokenX will increase its asset universe for investors and make trading more efficient using security tokens and smart contracts. Additional features may enable a digital market infrastructure that eliminates paperwork, reduces transaction costs, and cuts settlement times. The goal is to operate a network across Europe, U.S., and Asia, where security tokens are traded fully compliant to provide liquidity across SMEs, private debt, and real estate for new funding opportunities.

4.2.2.3 *Berner Kantonalbank and Daura*

The *Berner Kantonalbank AG* (BEKB) and *daura* developed the DLT-based infrastructure *SME-X* in cooperation with additional partners. *SME-X* enables the tokenization of securities from Swiss SMEs for new process improvements (e.g., instant-settlement, automated management of shareholder register) and novel market opportunities across issuance, transfer, and storage of digital assets. BEKB is one of the largest cantonal banks in Switzerland, with more than 1,200 employees, founded in 1834. Besides its banking offerings, it operates the trading platform *OTC-X* as a market leader in unlisted securities. *Daura* was founded in 2018 and employs more than ten people. The fintech operates its own tokenization platform and provides services to digitize shares of Swiss SMEs, where processes (e.g., capital increases) are facilitated and conducted more efficiently.

The technical platform of *daura* is based on a private permissioned DLT using Hyperledger Fabric to fulfill data protection and confidentiality requirements. The nodes are hosted by verified participants, where writing and reading access to transactional data is only allowed to a selected group. The legal framework for tokenizing the shares was developed in cooperation with the legal experts of *MME Legal AG*. It is assumed that the usage of DLT will bring significant efficiency gains and the potential to automate post-processing further. Besides *daura*'s own platform, the *SME-X* infrastructure also supports public permissionless DLTs (e.g., Ethereum), where the *Hypothekarbank Lenzburg* and its *Finstar* platform ensure the technical custody of the relevant cryptographic keys together with *Taurus*. In addition, all modules are integrated via an open architecture and meet existing regulatory standards.

Also known as the *digital asset ecosystem*, the platform may increase Switzerland's reputation as an innovative financial marketplace. It follows the vision to execute all processes across the lifecycle of a tokenized share ranging from issuance to trade and custody. While a focus lies currently in facilitating the exchange of unlisted securities from Swiss SMEs, other securities should stepwise be integrated.

4.2.2.4 NYALA

The German-based fintech *NYALA* was founded in 2021 as a spinoff of *Kapilendo AG*, a leading investment platform for SME investment projects. As part of a bigger company group (i.e., Invesdor) with between 50 and 200 employees, the fintech offers institutional investors and financial service providers novel product solutions and API services for digital assets. The offerings include, for example, custody (e.g., safe-keeping of digital assets), tokenization (e.g., issuance of digital securities), and crypto-asset servicing (e.g., trading, staking).

NYALA's digital asset platform is based on four API platform services. At first, it provides a fully licensed custody solution that offers a secure environment to store and manage cryptoassets. Secondly, it enables a BC-based solution to issue various digital assets (e.g., security token, utility token) while fulfilling regulatory frameworks. Thirdly, worldwide access to crypto exchanges is ensured to easily trade digital assets via interfaces that enable seamless integration in existing legacy or core banking systems. The fourth component is represented through a staking module, where digital assets are kept to validate transactions and receive compensation. Also, different cryptocurrency protocols are supported depending on the customer's market needs (e.g., Stellar Lumens, Ethereum). Among associated services, the company also provides tailored solutions, for example, the technical setup of productive use cases (e.g., issuance of a token-based bond).

NYALA will play a leading role in establishing *crypto-as-a-service* solutions for financial institutions. The company addresses the growing demand for digital asset products with its fully compliant infrastructure, providing the necessary frameworks and technical expertise. In addition, the company group and its subsidiaries hold licenses required to cover the whole spectrum and needs in digital assets, such as the *security registry license* issued by the German banking authorities that allow the storage of private keys in wallets for its clients.

4.2.2.5 *SIX Group*

With over 2500 employees, the *SIX Group* operates the infrastructure for the financial centers in Switzerland and Spain, providing services that ensure the processing of financial information and payments for financial market players. The name is an abbreviation of Swiss Infrastructure and Exchange, where the company bundles its activities primarily in three areas. Firstly, securities trading via the *SIX Swiss Exchange* relates to the admission of securities and the platform's operation. Secondly, the company acts as a counterparty and central securities depository in post-trade settlement, including platforms for inter-bank clearing. Thirdly, it offers additional services based on financial market information and payment transactions. In this context, SIX consistently increases efficiency and quality along financial value chains, where it also developed an innovative DLT-based infrastructure.

The *SIX Digital Exchange* (SDX) represents a fully regulated financial market infrastructure that enables integrated trading, settlement, and custody for digital assets based on DLT. It utilizes the private permissioned R3 Corda technology to improve the post-trade lifecycle. The solution allows an atomic settlement on ledger, using cash delivered to the exchange by a central bank. It facilitates entire workflows and is assumed to reduce settlement times, risks, and costs. Compared to traditional stock exchanges with a centralized clearing and settlement, the SDX may operate round-the-clock for investors, banks, and other service providers. The platform is designed to support a broad range of digital assets such as traditional asset classes (e.g., bonds, equity) and non-bankable assets. The SDX will provide a regulated environment for issuance and trading, especially for the digital representation of today's illiquid assets (e.g., real estate, art) using the concept of tokenization.

The platform went live by issuing a tokenized bond, including its listing and placement on capital markets at the end of 2021. It intends to extend operations to establish a secondary trading marketplace for security tokens, provide services around cryptocurrencies, and investigate digital currencies' applications. The goal is to create an ecosystem that

bridges the gap between traditional and decentralized financial services providing the roadmap for future financial infrastructures.

4.2.2.6 Bank Frick

The Liechtenstein-based *Bank Frick* is a family-owned bank with more than 160 employees founded in 1998. The institute offers a wide range of financial services focusing on financial intermediaries, specializing in tailored fund solutions and so-called state-of-the-art *blockchain banking*. In addition, it is Liechtenstein's only bank with acquiring licenses from MasterCard and Visa. With its banking license, the institute consistently expands its digital business to offer clients a one-stop-shop for fully regulated financial services.

As one of the leading banks for regulated blockchain banking, a platform has been developed to facilitate cryptocurrency trading for regulated market participants. In addition, the bank offers regulated fund solutions and associated services to support a compliant BC-based business in Liechtenstein (e.g., account management). In addition to technical expertise, Bank Frick provides advice regarding the Liechtenstein Token Act or establishing a blockchain business in Liechtenstein. A main component of the infrastructure is the regulated custody solution using cold storage to protect assets against theft or loss. The wallets are multiply encrypted and kept securely in various locations. Bank Frick enables professional market participants and intermediaries to trade leading cryptocurrencies (e.g., Bitcoin, Litecoin, Ethereum) and diversify their portfolio with bankable crypto investment products.

Bank Frick was one of the first market participants that focused on blockchain banking services early on, while it is now profiting from the growing demand for regulated cryptocurrency services. Together with the start-up Cadeira, they conducted a fully BC-based securitization of corporate loans. The institute assumes that traditional banking and crypto finance hold new business potential in the future and continues to lay the foundation for innovative services in a token economy.

4.2.3 General Findings

The findings from the six case studies show that the demand for digital assets and DLT-based solutions is consistently growing. Across all investigated companies, a diverse product portfolio is identified that ranges from new investment products and software-as-a-service solutions to consulting and advisory. All cases share the goal of providing regulated offerings compliant with existing legal frameworks, especially in the business-to-business (B2B) sector. Affluent customers and institutional clients (e.g., family offices, brokers, banks) are typically targeted. The increasing adoption of cryptocurrencies (e.g., Bitcoin, Ether) currently drives developments. It is no surprise that most case studies provide services for this new asset class to facilitate, for example, trading via dedicated platforms. Whether it is about cryptocurrencies or tokenized assets, a similar DLT-based infrastructure is needed. One of the key challenges is the secure storage of these digital assets using cryptographic keys compared to conventional custody processes. Many investigated platforms ensure availability, confidentiality, and integrity by offering highly safe and regulated custody services.

Interestingly, established institutions (i.e., BEKB, Bank Frick, SIX) and fintechs (i.e., NYALA, Amazing Blocks, Daura, StokenX) have recognized the potential for banking and implemented DLT-based systems in parallel to established financial market infrastructures. It is assumed that tokenization is the next driver for innovation beyond cryptocurrencies to optimize processes and enable new business models. All companies seek collaboration or participate in ecosystems to offer their services. The case studies show that the impact of digital assets and DLT-based solutions redefines roles and functions within the financial value chain rather than making its participants obsolete.

All case studies supported the construction of the artifact. Accordingly, the investigation of the six cases has to result in theoretical saturation as the point at which changes in the DSR process are minimal. After identifying no new insights in seven iterative design cycles, it can be concluded that theoretical saturation through this sample was met.

4.3 Modeling Approach

The conceptual model for asset tokenization is based on the DSR methodology, which supports a purposeful construction of IT artifacts and ensures their applicability in practice (Gregor & Hevner, 2013). The results represent solutions to an identified organizational problem grounded in existing knowledge and are based on iterative relevance, rigor, and design cycles (Hevner et al., 2004, p. 80). In this section, the modeling approach refers to the DSR guidelines by Peffers et al. (2007, p. 11) and follows a cyclical six-step research design consisting of *problem identification*, *defining objectives*, *design and development*, *demonstration*, *evaluation*, and *communication*. As shown in Figure 4-5, various methods have been applied to ensure rigorous construction and evaluation. The different phases are listed in detail below.

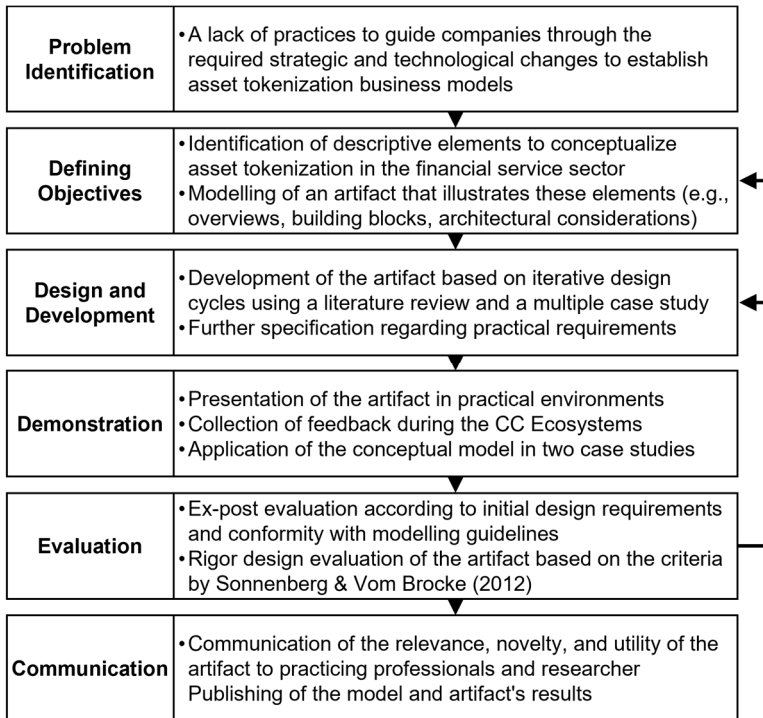


Figure 4-5: Modeling approach following Peffers et al. (2007, p. 11)

Problem identification: The design process is initiated by identifying an initial demand for the proposed artifact. Accordingly, practitioners stated the need for conceptual guidance in designing asset tokenization in its complexity and varying levels of abstraction (Section 2.6.1). The topic is still under-researched, where gaps in existing literature further underline the relevance and importance of a solution (Section 2.6.5).

Defining objectives: A review of foundational modeling approaches and related work (Section 4.1) addressed how a new artifact may solve the identified problem. Experts were asked what solution was needed (cf. CC8 WS2, WGI). As a result, a set of design requirements for a conceptual model was derived (Section 4.3.1).

Design and development: The artifact is developed using primary and secondary data in iterative design cycles. The initial conceptualization is conducted through a systematic literature review on selected model elements (Section 4.3.2). A build-demonstrate-evaluate approach with six case studies allowed descriptive insights to develop the model further (Section 4.3.3). Additional refinement was also considered during the CC Ecosystems (cf. CC8 WS4, WS6, WGIII, WGIV).

Demonstration: By applying the artifact to solve the identified organizational problem, the usage of the conceptual model was demonstrated in two case studies (Section 4.5). Besides its applicability within company environments, feedback was also collected during doctoral seminars, lectures, and associated workshops of the CC Ecosystems.

Evaluation: Findings were drawn from the demonstration and application of the model to assess to what extent content-driven design requirements were met (Section 4.6). For ensuring rigor, the artifact was also evaluated using semi-structured interviews and key criteria of Sonnenberg & Vom Brocke (2012) during the multiple case study.

Communication: The artifact is disseminated to researchers and management-oriented audiences by highlighting the practical relevance of designing innovative business models and addressing empirical

groundwork on a token economy. The underlying dissertation documents the results and supports the diffusion of this knowledge.

Before the outcomes are presented, the following sections specify the research activities to conform with the general modeling guidelines in a scientifically sound manner. First, the objectives of the solution are outlined by illustrating relevance and rigor criteria formalized as design requirements. Second, the initial conceptualization of the model is presented by drawing on data collection and analysis using a comprehensive literature review. Thirdly, the chapter concludes with a brief illustration of the artifact iterations by describing the development of the model during the multiple case study approach.

4.3.1 Design Requirements

One of the core goals of DSR is to ensure the creation of both relevant and rigorous artifacts (Winter, 2007). Accordingly, it is of interest that the model fulfills a particular set of objectives to be classified into two groups. On the one hand, content-driven criteria⁶ address the model's applicability in practice, and, on the other hand, quality-driven criteria⁷ refer to modeling guidelines based on theory. They can be described in terms of design requirements that reflect the objectives of the solution and serve as indicators for evaluation. Based on physical and virtual meetings, the relevant requirements were derived during the CC Ecosystems (cf. CC8 WS2, WGI), explicating the objectives of a solution. The results were complemented by reviewing foundational modeling approaches and existing work on DLT-based architecture frameworks. After refinement, the findings were consolidated into a list with fourteen design requirements that serve as a basis for orderly modeling and purposeful development (Table 4-2; Table 4-3).

The artifact aims mainly at practitioners (e.g., business architects, technical consultants) and provides a set of elements to design a conceptual architecture for asset tokenization business models. It represents a

⁶ Formalized design requirements derived from the DSR relevance cycles (cf. Hevner, 2007, p. 89).

⁷ Methodological requirements that stem from the DSR rigor cycles (cf. Hevner, 2007, p. 90).

model that specifies layers, such as network roles, governance, processes, services, systems, and environmental factors, including overviews, building blocks, definitions, and architectural considerations.

No.	Content-driven requirements
DR1	A <i>comprehensive blueprint</i> with dedicated elements to describe, analyze, and establish asset tokenization in the financial services sector.
DR2	<i>Strategic guidance</i> in conceptualizing value creation across multiple actors within the network to illustrate inter-organizational settings, activities, and interactions related to the tokenization of assets.
DR3	<i>Functional knowledge</i> about the value chain of tokenization highlighting relevant core processes to deliver associated products and services.
DR4	<i>Technical advice</i> in designing DLT-based architectures to assess and introduce new applications for the tokenization of assets.
DR5	An <i>integrated approach</i> to capture the configuration and setup of asset tokenization business models by describing all integral parts according to a layer-based model (e.g., network composition, technical implementation).
DR6	A <i>multi-dimensional scope</i> that involves various views on DLT-enabled asset tokenization (e.g., business ecosystem, organizational, process, and technical perspective) to provide a basis for different users and application contexts.
DR7	A <i>consistent terminology</i> that both business and IT stakeholders understand to describe use cases and business models associated with asset tokenization and its surrounding phenomenon.

Table 4-2: Design requirements based on content-driven criteria

In addition to the content-driven criteria, rigor design requirements are also met by several quality-driven standards. They refer to guidelines of orderly modeling and are derived from existing literature. The DSR process is supported through criteria to be considered during the evaluation of the model (Sonnenberg & Vom Brocke, 2012). Moreover, selected principles of reference modeling by Vom Brocke (2007) are introduced to increase usability and acceptance in general.

No.	Quality-driven requirements
DR8	<i>Completeness</i> : The state of being whole and complete while there are no redundant parts or missing elements.
DR9	<i>Real-world fidelity</i> : The quality of representing, illustrating, or describing the real world as an immaterial and abstract representation of reality.

DR10	<i>Internal consistency</i> : The attribute of being internally consistent and logically stringent among all elements.
DR11	<i>Level of detail</i> : The state of appropriate detail and granularity among all elements represented.
DR12	<i>Robustness</i> : The property of being applicable in practice and resisting varying contexts without fundamentally changing the initial state.
DR13	<i>Reference character</i> : The ability to instantiate, specify, or draw analogies from a concrete application-oriented context or configure and aggregate elements for an individual application scenario.
DR14	<i>Level of innovation</i> : The degree of providing an innovative contribution to the knowledge domain by conducting novel, incremental, or unique research.

Table 4-3: Design requirements based on quality-driven criteria

According to the artifact's requirements, it has to be taken into account that the design of a formalized reference architecture may go beyond the objectives of the dissertation. Although the model may address aspects of the enterprise architecture domain (e.g., technical specifications, guidelines, or notations), it primarily focuses on conceptual descriptive elements. Therefore, the development of associated methods is not considered part of this thesis. It can be stated that the conceptual model constitutes the first foundation to enable a successful solution design for asset tokenization in an abstract but sound manner.

4.3.2 Conceptualization

The design of artifacts requires an iterative approach that draws from both the application domain (cf. relevance cycle) and the existing knowledge base (cf. rigor cycle) (Hevner et al., 2004). Accordingly, a structured literature review was conducted to generate an initial overview of model elements and establish a basis for subsequent design and development. The scope of relevant articles builds upon the study of DLT-based architecture frameworks (Section 4.1.2) and follows methodological recommendations from prior research (Vom Brocke et al., 2009; Webster & Watson, 2002). Known scientific databases (i.e., EBSCOhost, IEEE Xplore, AIS eLibrary, Science Direct, ProQuest, and ACM Digital Library) were selected for academic literature in the business information systems domain. A title and abstract search was conducted with the search string ("*blockchain**" OR "*distributed ledger**")

AND (“platform*” OR “model*” OR “framework*” OR “architecture*”) in June 2021, covering all databases and periods of publications. The search process is depicted in Table 4-4, where 3949 documents were initially identified. Next, the abstracts and titles according to the research objectives were analyzed, and non-peer-reviewed articles were further excluded. After the full-text screening, an initial set of 42 documents served as a basis for a subsequent iteration of backward and forward-searching. Thus, a total of 83 publications could be considered.

Search string: (<i>blockchain*</i> OR <i>“distributed ledger*”</i>) AND (...)	Search field	EBSCO-host	IEEE Xplore	AIS eLibrary	Science Direct	Pro Quest	ACM
<i>platform*</i>	Title & abstract	431 (332)	382 (308)	9 (8)	263 (211)	29 (24)	13 (13)
<i>model*</i>	Title & abstract	724 (575)	424 (252)	22 (22)	46 (43)	296 (251)	30 (26)
<i>framework*</i>	Title & abstract	443 (201)	486 (286)	55 (53)	322 (226)	145 (122)	33 (26)
<i>architecture*</i>	Title & abstract	342 (296)	372 (323)	4 (4)	236 (201)	152 (118)	20 (20)
Sum (After non-English removed)		1940 (1404)	1664 (1169)	90 (88)	867 (681)	622 (515)	101 (92)
Import into citation manager							3949
Sum (After title & abstract screening)							208
Sum (After full-text screening)							42
Sum (Including backward & forward-searching)							83

Table 4-4: Results of the literature search process

After collecting the final set of articles on the current state of the art, the results are analyzed and structured to identify relevant elements and build the first iteration of the model. Therefore, a concept matrix is developed to provide an overview and facilitate discussions (Salipante et al., 1982; Webster & Watson, 2002). Categories and topic-related concepts were identified through thematic analysis (Braun & Clarke, 2006). Following the six steps (i.e., familiarize yourself with the data, generate initial codes, search for themes, review themes, define and name themes, and produce the report), nineteen themes were conceptualized

to semantically describe and group similar model elements of the publications (e.g., inter-organizational layer, process layer, value chain roles, environmental aspects). The concept matrix of the review is presented in Appendix E.1, where selected elements were transferred into a first blueprint with different overviews, building blocks, definitions, and architectural considerations. Building upon this foundational work, the related results represented a useful conceptual reference and provided an appropriate framing (e.g., Abreu et al., 2020; Notheisen et al., 2017; Rauchs et al., 2018). Initially, the first iteration of the artifact consisted of a high-level model overview of four layers (i.e., network, process, service, and technology), where each layer was explicitly addressed in terms of additional sub-elements.

4.3.3 Iterative Design Cycles

Practical insights complement the initial findings and uncover new knowledge to design and refine the artifact iteratively. For that reason, a qualitative research approach based on multiple case studies is conducted to explore how companies develop, implement, and operate businesses associated with asset tokenization. Following Yin (2013), case study research enables an in-depth investigation of phenomena by obtaining empirical data from a real-world context. This method is highly relevant in capturing complex interrelationships in practice, especially for the under-researched and nascent domain of asset tokenization. Based on the recommendations for case study research (Dubé & Paré, 2003; Yin, 2013), multiple real-world examples for data collection and analysis were considered to establish a broader foundation of descriptive knowledge.

According to predefined selection criteria (Section 4.2.1), six different cases with seven participating companies (e.g., fintechs, banks) were investigated in their practical environment from July 2021 to February 2022 using different types of data sources (e.g., business information, company reports) and data collection techniques (e.g., expert interviews, questionnaires). In these cases, representatives from the organizations worked closely with the researcher in several cycles, applying

a build–demonstrate–evaluate workflow for the specific elements to be designed (Table 4-5). Thus, in a series of meetings with executives, product managers, and other roles with expertise in tokenization, semi-structured interviews provided the data to systematically gather insights for the iterative design of the artifact (i.e., requirements engineering). The thirteen interviews with an average of 63 minutes were conducted in three rounds, documented, and analyzed based on a qualitative coding approach by Gioia et al. (2013) with an overview in Appendix E.2.

	Amazing Blocks	Stoken X	BEKB	Daura	NYALA	SIX Group	Bank Frick
<i>Design Elements</i>	[1]	[2]	[3]		[4]	[5]	[6]
Model Overview	X	X	X	X	X	X	X
Network Roles	X	X	X		X	X	X
Network Governance	X	X			X	X	X
Processes	X	X	X	X	X	X	X
Services	X	X	X		X	X	X
Technology	X	X		X	X		X
Environment	X	X	X		X	X	X

Table 4-5: Overview of case studies and design of elements

Based on semi-structured interview guides (Appendix E.3), the practitioners were introduced to the setup and problem domain in the first rounds. Regarding the model overview and sub-elements, it was possible to challenge the artifact by adding a new layer (i.e., environment), redefining descriptions (e.g., network roles), and specifying technical building blocks (e.g., physical layer). During the second round, an additional refinement across the artifact took place. Accordingly, various aspects have been revised (e.g., environmental factors) and included (e.g., security layer for technical implementation). Finally, a design evaluation was conducted to determine finality and applicability in a third-round (Sonnenberg & Vom Brocke, 2012).

Secondary data on the cases from online research (e.g., company websites, reports) further complemented the findings. In this context, the CC Ecosystems served as an additional basis to generate practical insights for reevaluation and development (cf. CC8 WS4, WS6, WGIII, WGIV). More than 120 changes were documented in a spreadsheet

and considered in the process, where the initial model was redesigned and adapted in seven iterative design cycles. As a result, the final artifact represents a comprehensive foundation that provides a shared understanding of a complex system with varying levels of abstraction.

4.4 Conceptual Model Description

The dissertation's second research question addresses the elements to conceptualize asset tokenization in the financial services sector. As a result, the artifact is presented that incorporates these elements as an abstract foundation to design a holistic value architecture for such innovative business models. The goal is to introduce the conceptual model, its building blocks, overviews, definitions, and architectural considerations to ensure a consistent understanding of its application in practice and academia. The first section describes the model overview with its five generic layers: *network*, *processes*, *services*, *technology*, and *environment*. Then, each layer is addressed explicitly through a separate section with more detailed elements and associated building blocks.

4.4.1 Model Overview

The artifact builds on a modular and multi-layered approach to support the comprehensive conceptualization of asset tokenization and practical instantiation of solutions. Figure 4-6 introduces the model overview, which provides an integrated perspective on interconnected layers and pivotal elements for value creation. A layer model is primarily known for designing socio-technical systems and generally allows the construction of complex structures while ensuring a certain degree of standardization and flexibility (Baldwin & Woodard, 2008; Tilson et al., 2010). From an architectural perspective, it facilitates the configuration by covering not only different levels of abstraction but also providing detailed building blocks for each layer to be separately considered or applied as a whole. The artifact follows a top-down approach ranging from strategic, processual, and technical elements to support a holistic business model design. While a specific description of the five layers is found in the respective sections, a first overview is given below.

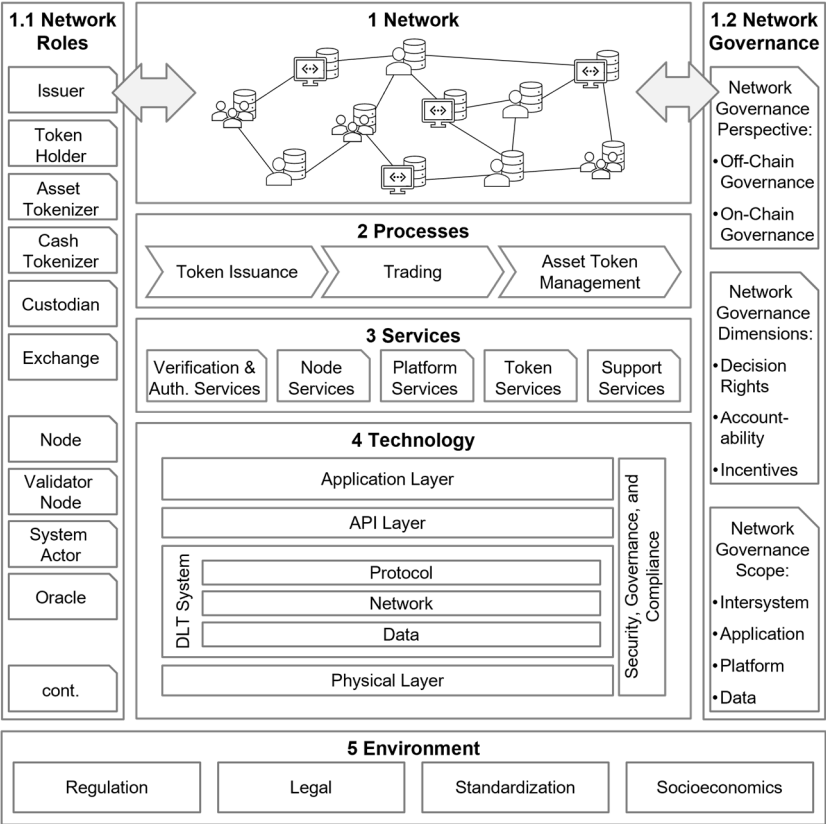


Figure 4-6: Model overview and respective elements

(1) *Network*: At the highest level of abstraction, the layer defines the basic setup of value creation and the business logic, focusing on required entities, functions, and interactions (Seebacher & Maleshkova, 2018). One focus lies on (1.1) *network roles* representing the entities that perform a specific role within the network to directly or indirectly enable value creation, including organizations, individuals, or distinct parts of the DLT-system (e.g., nodes). In addition, (1.2) *network governance* defines the mechanisms, rules, and processes required to ensure accountability, decision-making, participation, and interaction for designing, implementing, and operating the network (Liu et al., 2021).

(2) *Processes*: The layer illustrates the end-to-end processes to describe, structure, and model the related activities in asset tokenization value creation and delivery. The reference process is represented through macro process steps, where each step is further detailed into respective sub-processes (Reitbauer et al., 2008).

(3) *Services*: From a market perspective, the layer describes the products, services, and related offerings that create value and meet customer needs based on business models associated with the tokenization of assets (Osterwalder, 2004).

(4) *Technology*: The layer specifies the general functionality and the essential system components of a DLT-based architecture to provide a conceptual foundation for implementing asset tokenization use cases (Seebacher & Maleshkova, 2018).

(5) *Environment*: As the framework's foundation, the layer captures environmental aspects that either constrain or encourage the development and operation of services and business models associated with the tokenization of assets (Notheisen et al., 2017).

The presented layers and their elements are interrelated with each other. For example, an individual network role (e.g., asset tokenizer) may perform a specific sub-process (e.g., token issuance) that, in turn, supports the creation of a particular service (e.g., tokenization). An illustration of the model's constituents and relationships can be found in Appendix E.4. Since the building blocks within each layer represent potential configurations of asset tokenization, an instantiation depends on a particular tokenization use case chosen for implementation. The tokenization of *illiquid assets* requires, for example, other entities (e.g., physical safekeeper) compared to *service access* using tokens. The (1) *network*, (2) *process*, (3) *service*, and (4) *technology* layer include more specific design options than the (5) *environment* layer representing abstract elements as external preconditions to be met for establishing a business model at all (e.g., legal requirements, customer demand). An initial focus lies on the network's description as a critical layer of

whether and how use cases can be established (Notheisen et al., 2017; Seebacher & Maleshkova, 2018). Accordingly, the first four layers are structured according to their degrees of abstraction ranging from highest (cf. network) to lowest (cf. technology). A set of basic assumptions for the model are defined below to provide an understanding of its application context and specify its practical scope:

- In an organizational context, the model aims at practitioners from the innovation (IT) strategy, business architecture, technical consulting, and requirements engineering domain primarily situated in the financial service sector.
- Due to external factors (e.g., banking compliance), it is assumed that financial intermediation will be required and still be of great importance in the medium term. Accordingly, the model is based on an integrated view of centralized and decentralized infrastructures to redefine traditional functions in the financial value chain rather than eliminate existing participants.
- The model fully demonstrated its applicability to cover the value creation of business models associated with *asset tokens* (Section 3.3.1, p. 74). In addition, analogies also imply coverage for other identified archetypical use cases (Section 3.4.3), including *utility* and *payment tokens*.
- Based on a construction-oriented paradigm (cf. reference modeling), the model complements other design frameworks (e.g., business model canvas) by providing a set of descriptive elements. However, the model is not part of a broader method for transformation (cf. method engineering), nor does it illustrate the impact of asset tokenization (cf. explanatory research).
- The model and its elements are characterized by a certain degree of abstraction to ensure applicability and comprehensiveness for representing as many configurations of asset tokenization use cases and business models as possible.

4.4.2 Network

The study of networks is a well-known area in management science and IS research by focusing on an investigation of distinct elements and their connections between them (Provan et al., 2007). Various concepts have emerged (e.g., virtual organizations, business ecosystem) that describe the relationships between companies for accomplishing overarching business objectives collaboratively (e.g., Adner, 2016; Sydow, 1992). To specify the importance of networks for the conceptual model, the initial definition of *business networks*⁸ by Hakansson & Snehota (1994) is chosen and further extended. By defining networks as value-creating systems with two or more entities, value is generated through IT-supported processes and core competencies (Alt & Legner, 2008; Normann & Ramírez, 1993). In this context, additional coordination principles are required to maintain competitive advantage (Köhne, 2006).

As a result, the *network layer* focuses on both the participating *network roles* and *network governance* to provide strategic guidance and instantiate specific settings based on predefined definitions and building blocks. As the first step for conceptualization, the layer aggregates the relevant entities, functions, and interactions that constitute an abstract composition for value creation in asset tokenization business models. While DLT follows a distributed logic among different components (e.g., computing nodes, on-chain data), integrating such shared digital infrastructure requires far more collaboration between organizations. Therefore, modeling this layer allows a first illustration and mapping to design innovative decentralized solutions and fully realize distributed services associated with the tokenization of assets.

The following sub-section focuses on the identified network roles for value creation. Then, the elements of network governance are introduced to specify accountability, decision-making, participation, and interaction within the network and its roles.

⁸ Hakansson & Snehota (1994, p. 21) introduced the initial term *business network* to describe an inter-firm cooperation that allows companies to accomplish certain overarching objectives.

4.4.2.1 Network Roles

The concept of tokenization is considered highly transformative, with significant implications for traditional financial value chains and their participants (Harwood-Jones, 2019). Especially DLT as the underlying technology and its network of separate computing devices (i.e., nodes) can affect both existing structures and processes. For example, separate entities can host validator nodes, so services do not necessarily rely on one centralized party to settle transactions. In addition, the transfer of cryptocurrencies requires a securely stored private key to prevent non-authorized access to personal wallet accounts (Section 2.1.2). Based on this, DLT-driven infrastructures and platforms offer opportunities for new players in financial markets and may also lead to the re-intermediation of incumbents, performing activities across the token lifecycle that did not previously exist (Chiu & Shang, 2019).

Based on current developments, the conceptual model introduces various entities at the network layer. Each entity takes on a specific role and carries out activities related to asset tokenization directly (e.g., trading of tokens by accountable provider) or indirectly (e.g., transaction validation of tokens by nodes). As suggested by Rossi et al. (2019), DLT-enabled entities are also considered to account for the socio-material nature of such systems. In this context, the single roles cover organizations, individuals, and distinct parts of a DLT-system. The entities represent the smallest reasonable functional unit and are grouped into four main categories based on their activities in the network. A separate table is created for each category, describing the activities of each role and listing practical examples. In particular: *tokenization value chain roles* (Table 4-6), *DLT-based platform roles* (Table 4-7), *DLT-based technical roles* (Table 4-8), and *DLT-based system roles* (Table 4-9). A short description of the practical examples is given in the Glossary. Finally, after identifying the relevant entities, it is helpful to represent relationships through linkages using a basic structure or formalized modeling approaches (e.g., e3-value method). Following this, it should be considered that the roles might be extended and that the same entity can act in different roles by performing multiple activities in the network.

Role	Description of Tokenization Value Chain Roles	Example
Token Holder	acquires tokens for an individual purpose, ranging from investment to usage in applications (e.g., DApps, voting). A user may also keep tokens to become a prosumer (e.g., mining or staking to operate a node).	Retail Investors
Issuer	provides the vehicle to raise funds, prepares token sales, and other tasks associated with token issuance (e.g., publish terms & conditions, carry out marketing & communication).	Daura
Asset Tokenizer	digitizes an asset (e.g., physical, digital, contract) in the form of a DLT-based token by embedding a bundle of rights into a smart contract (e.g., transfer of asset ownership).	Amazing Blocks
Cash Tokenizer	issues and provides digital cash tokens (c.f., fiat-backed stable coins, utility settlement coins) to ensure on-chain-settlement for a simultaneous transfer of ownership rights with an asset (e.g., DVP). Cash tokens should be backed by fiat currencies (i.e., cash-on-ledger).	Paxos
Physical Safekeeper	is responsible for storing the physical asset in a proposed quality and quantity represented by a token. The role provides a bridge and ensures coordination between the token and its backed real-world object or counterpart.	Fine Wine Capital
Physical Validator	ensures the existence and enforcement of contractual obligations of the token holder between the digital- and physical world represented on the distributed ledger under consideration of legally binding law.	Notary
Custodian (Custodial, Non-Custodial)	provides the infrastructure for storing and safekeeping private keys (e.g., wallet). The role may also include access and maintenance of the account on the customers' behalf (custodial) or by the user itself (non-custodial).	InCore
Exchange (Central, Decentral)	provides the platform for approving, routing, and placing buy and sell orders of tokens. The coordination of supply and demand is managed centrally or decentrally (c.f., DEXes), focusing on <i>token-to-fiat</i> or <i>token-only</i> transactions.	Coinbase, Uniswap
Regulator	monitors all participants and associated processes to ensure the market's integrity regarding existing legal frameworks (e.g., regulated digital asset trading).	FINMA, BaFin
Financial Service Provider	represent entities that provide services and act as intermediaries among various parties to facilitate token transactions from a technical and business perspective. For example, banks are responsible for advising and selling to end customers as a bridge between cash-on-ledger or the fiat currency network. Brokers provide secondary trading of newly issued digital asset tokens.	BEKB, TokenX

Table 4-6: Overview of tokenization value chain roles

The *tokenization value chain roles* in Table 4-6 present the first category of entities to establish an understanding of asset tokenization from an inter-organizational perspective. Based on the identified core competencies, the definitions and activities allow the description of inter-firm cooperation and value creation within a network of organizations and individuals. In comparison to existing structures, it can be stated that four new roles come into existence to provide novel functions in token-based infrastructures, namely: *asset tokenizer*, *cash tokenizer*, *physical safekeeper*, *physical validator*. While two existing roles remain primarily unchanged (cf. token holder as customers, regulator), it is assumed that the remaining roles (e.g., financial service provider) have to adapt their activities in response to novel infrastructure requirements, products, and services (e.g., custody of cryptographic keys).

Role	Description of DLT-based Platform Roles	Example
DLT Infrastructure Provider	provides the DLT-based infrastructure (e.g., DLT- framework, smart contract language) with respective functionalities (e.g., Turing completeness). The infrastructure maintains the DLT-protocol code base and serves as a basis for further developments and implementations of the application provider.	Ethereum, R3 Corda
DLT Application Provider	develops integrated applications for on-chain services (e.g., identity management, tokenization) and off-chain services (e.g., storage, payment) that operate on top of the DLT-system. The role may also cover the provision of scripts, testing tools, and additional infrastructure elements (e.g., DLT backend, frontend) (Rauchs et al., 2018).	ConsenSys
DLT Consortium	fosters participation between different stakeholders for achieving a common goal in DLT-research or development projects (e.g., sharing resources, know-how). Consortia are divided into business-oriented (e.g., members solve business problems) and technical-oriented (e.g., platform development), leading to industry cooperation, standardization, and best practices.	Hyperledger Foundation, B3i
DLT Community	drives market adoption, development, and acceptance within the DLT ecosystem based on an open-source approach. Often incentivized by tokens in return, contributions include, for instance, DLT code base and DApp development, mining, funding, whitepaper creation, legal expertise, or marketing.	DeFi Community

Table 4-7: Overview of DLT-based platform roles

As shown in Table 4-7, the second category specifies the *DLT-based platform roles* associated with the operationalization of products and services using DLT. The roles define all activities to provide decentralized platforms based on technical considerations and the surrounding developer ecosystem. DLT-based platforms consist of a modular architecture, where multiple entities can separately operate the architectural layers (cf. application, logic, data) (Alt, 2021). Compared to centralized applications typically owned by one provider, DLT-based platforms rely on both *DLT infrastructure* and *DLT application providers*. As a result, collaborative industry partnerships are usually established through *DLT consortia* based on technological or business-oriented interests. Moreover, as the open-source approach is a fundamental feature of the technology, *DLT communities* are also significant drivers for developing applications and decentralized platforms.

Role	Description of DLT-based Technical Roles	Example
Developer	writes, reviews, and deploys code for developing functional components of a DLT-system. Development may include end-user applications, APIs, DLT components (e.g., smart contract logic, consensus protocol), and integrated non-DLT components (e.g., off-chain storage).	Smart Contract Developer
Tester	ensures end-to-end functionality of the overall application based on testing scripts and different user scenarios. The function includes reporting to the developer and clarifying what actions led to an error.	Software Tester
Administrator	manages the codebase repository and serves as maintainer that controls access and decides to add, remove, and change the source code of the operating DLT-protocol with implications for on-chain governance processes. The nature and setup of the administrator role can significantly vary to be assigned by one or more entities following a specific decision-making process (cf. governance of <i>decision control rights</i> , p. 141) and a predefined decision proposal (cf. governance of <i>decision management rights</i> , p. 141).	Bitcoin Core Lead Maintainer

Table 4-8: Overview of DLT-based technical roles

The DLT-based *technical roles* in Table 4-8 illustrate the third category of entities within the network. They include the description of one or more individuals to maintain the DLT-based platform and engage in

technical activities associated with the system. DLT requires, in general, an extension of skillsets, knowledge, and expertise to meet the responsibilities for planning, development, and operation (Mendling et al., 2018). After identifying inter-organizational aspects, the roles can support an effective resource allocation and ensure operational alignment with existing capabilities. Selecting a suitable DLT type for a particular use case requires a broad knowledge of cryptography, database design, or distributed computing. Also, the testing of applications involves a comprehensive set of components, tools, and approaches. In addition to *developer* and *tester*, a focus lies further on the *administrator* role who curates the platform and maintains the codebase repository of an underlying DLT protocol. Although the presented roles are strongly related to DLT-systems, they also provide a basis for other technical functions and can be further adapted or complemented.

Role	Description of DLT-based System Roles	Example
Node	serves as a communication point within a network of other nodes (e.g., peer-to-peer network) with (partly) reading and writing access to the DLT-system. Depending on the DLT-protocol, they are responsible for various network functions like creating, receiving, or sending information designed to validate and maintain replications of transactional data. Nodes are divided into full nodes (i.e., a full copy of transactions) and lightweight nodes (i.e., partial history of transactions) relying on single storage and computing devices (e.g., server) individually owned, managed, and operated.	Block-daemon
Validator Node	proves requests of transactions and validates them based on a predefined validation mechanism. Depending on the DLT-protocol, validator nodes further replicate the transactional data throughout the network of nodes. A miner is defined as an anonymous validator node using a specific consensus algorithm (e.g., proof of work) for validating public instead of private transactional data to be incentivized by rewards for every transaction successfully added to the system.	Bitcoin Miner
System Actor	refers to a virtual identity of an actor established within a DLT-system, where every node has a unique reference (e.g., attached to a computing device, individual owning a crypto wallet) to be distinguished from other nodes in the network. The reference differs in using pseudonymous on-chain or known off-chain identities to create trust.	Bitcoin Adress of a Wallet

Oracle	transmits external data to the DLT system and provides services associated with verification and authentication of usually integrated data sources based on trusted APIs.	Chainlink
--------	---	-----------

Table 4-9: Overview of DLT-based system roles

The last category highlights the *DLT-based system roles* in Table 4-9 that relate to functional components involved in the operation of the DLT-based platform from a systems perspective. Following Rossi et al. (2019), a socio-material nature of DLT-based networks can be identified considering the interaction between human agents and the DLT protocol itself. It can be further stated that the “*protocol is imbricated with the human agents’ social world. This means that both are simultaneously interdependent, yet maintain their distinct irreducible character*” (Rossi et al., 2019, p. 1392). On that basis, activities of DLT-system components are derived that are performed either through an individual, group, organization, or even a fully decentralized entity with no central leadership (cf. decentralized autonomous organization). Bitcoin miners, for example, represent *validator nodes*, where the network participants receive Bitcoins by solving a computational puzzle and maintaining the ledger of transactions. For the network layer, additional entities (cf. nodes, system actor, oracle) are defined to reduce ambiguity and support application development based on the most granular functions.

4.4.2.2 Network Governance

Today's digital business models rely on platforms to offer goods and services, typically owned, controlled and operated by a single party (Perscheid et al., 2020). Compared to a central entity developing and managing a platform, DLT enables the creation of asset tokenization networks that are not only distributed but moreover decentralized. As the technical basis of many cryptocurrencies, public BCs rely, for example, on a network of separate computing devices that may imply an unlimited number of nodes to be hosted by unknown pseudonymous users. Also, private DLTs integrated as part of a broader IS application can lead to combined governance structures consisting of various centralized and decentralized elements (Beck et al., 2018). However, DLT

may enable new forms of governance and interaction through predefined rules embedded and automated in computer code itself (cf. On-chain governance) (Zavolokina et al., 2020). As stated by Rossi et al. (2019, p. 1392), the usage of DLT may direct “*attention not only to governance of information technology, but also to governance through information technology.*” Therefore, the various implications require a reconsideration of established notions of governance in asset tokenization networks across all participating roles. Whether it may affect the responsibilities to be distributed among multiple organizations, the decision-making processes for further development of the platform, or the accountability of individuals for the operation of the system, it is assumed that conventional IT governance frameworks cannot be applied in presence of distributed control (Liu et al., 2021).

As a result, the conceptual model presents a set of elements to define the mechanisms, rules, and processes that ensure accountability, decision-making, participation, and interaction for designing, implementing, and operating the network with its roles. To the best of the authors' knowledge, a comprehensive overview of best practices is still missing (De Rossi et al., 2019). Based on the existing roles in the network, the goal is to establish a first conceptual governance model from multiple perspectives. The elements are depicted in Figure 4-7 and are grouped into three major categories as equally important building blocks. The (I) *network governance perspective* focuses on how governance can be established. The (II) *network governance dimensions* specify which options can be taken within three predefined areas of action (cf. decision rights, accountability, incentive mechanisms). The last category, (III) *network governance system scope*, refers to the instance in the network (e.g., inter-organizational, DLT-system) that should be governed.

In this context, the various aspects allow the design of a governance structure that supports all stakeholders to engage in related activities and meet organizational requirements effectively and collaboratively. For example, the different governance principles may apply to a particular solution resulting in hybrid structures across the DLT-platform, the

network, and its participants. The three categories are specified based on their building blocks and definitions in the following sections.

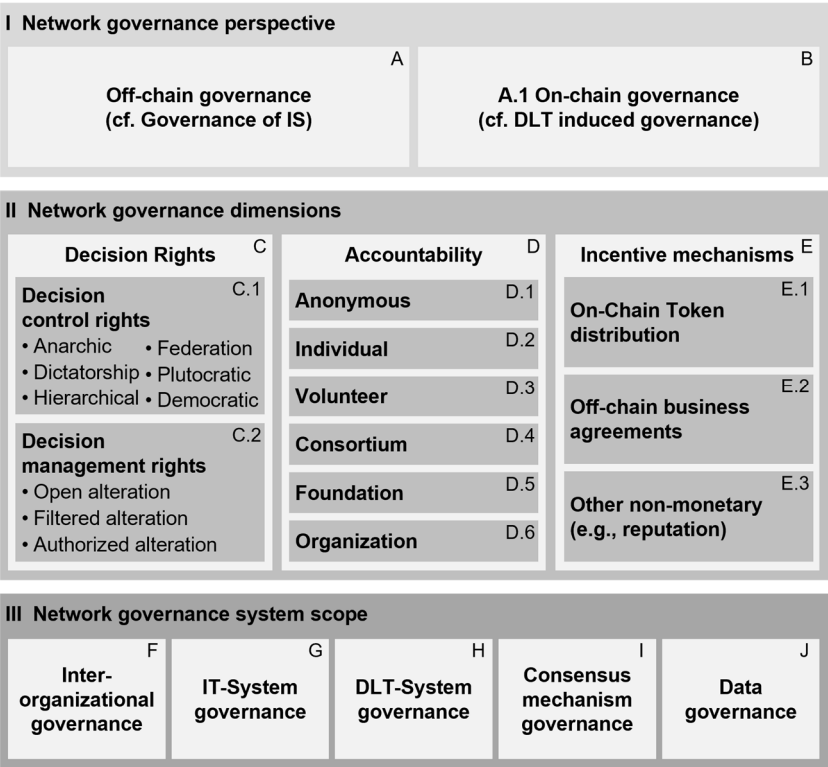


Figure 4-7: Overview of network governance

(I) *Network Governance Perspective*: Regarding DLTs' capability to enforce agreements and achieve cooperation and coordination, the network governance perspective differentiates between *off-chain governance* (A) as a perspective to govern a DTL system from the outside and *on-chain governance* (B) representing a DLT induced governance (Table 4-10). This duality has its roots in the technical infrastructure, where the DLT allows the operation of a distributed database for transactions within a peer-to-peer network of nodes without mediation by a central instance. However, a mechanism between the equally privileged participants is required to agree on one global state in case of conflicts (cf.

concurrency control). As part of the DLT protocol, the consensus mechanism (Section 2.1) technically ensures this data consistency to establish an agreement in the absence of a single authority (Liu et al., 2021). Therefore, the ability to delegate responsibility, obligations, and trust from one centralized party into the network itself can be perceived as a form of distributed governance. Accordingly, Rossi et al. (2019, p. 1392) mention that *“human agents govern the blockchain protocol, and the blockchain protocol governs their interactions.”* Combined with smart contracts (Section 2.1.3), the technology can further enforce accountability through codified rules once specific conditions are met. One example is a *decentralized autonomous organization*, in which smart contracts automatically execute transactions based on predefined rules and replicated business logic (Beck et al., 2018).

2nd Level Category	Description
Off-chain governance (A) (cf. governance of DLT systems)	By following a socio-technical logic, DLT systems are perceived as objects to be externally governed. From that perspective, the source of control ultimately resides outside the DLT system with a governance regime enforced on it (e.g., ensuring the interoperability between DLT systems with other systems) (Perscheid et al., 2020).
On-chain governance (B) (cf. DLT induced governance)	Governance is achieved through on-chain technically enacted mechanisms (e.g., DLT protocol code, smart contracts) following the logic of algorithmic governance. Rules are codified and distributed across nodes that define which actors are allowed to participate and how they interact with the system (e.g., decision-making, conflict solving, voting mechanisms). Following this perspective, the source of control primarily resides inside the DLT-system (Perscheid et al., 2020).

Table 4-10: Network governance perspective

As shown in Table 4-10, it can be stated that on-chain governance fosters the overall trust in the system and facilitates collective decision-making. In comparison, off-chain governance builds upon existing IT practices and does not rely on any form of technology-induced mechanisms. However, implementing on-chain governance may still require combining these two perspectives as regulatory and legal requirements must be considered in practice (Zavolokina et al., 2020).

(II) *Network Governance Dimensions*: The technical features of DLT offer a new approach to governing decentralized platforms. As a result, guidance is required that provides not only direction for the current and future governance of the asset network but also defines the potential scope of actions to be taken. In this context, Weil (2004, p. 3) defines IT governance as a “*framework for decision rights and accountabilities to encourage desirable behavior in the use of IT.*” Building upon these findings, Beck et al. (2018) further extend this definition and specify three dimensions as a part of a broader *BC economy governance framework*. These abstract dimensions were further refined to serve as a basis for three distinct building blocks within the conceptual model. As shown in Table 4-11, the network governance dimensions involve *decision rights* (C), *accountability* (D), and *incentive mechanisms* (E) and are complemented in Table 4-12 with more detailed design options. For example, the accountability of a DLT-based platform for asset tokenization can be established via consortia or a set of individuals.

2nd Level Category	Description
Decision rights (C)	The authority, responsibilities, and capabilities of entities enable decision-making processes for governing a system. For example, decision-making can occur <i>on-chain</i> or <i>off-chain</i> and involves key decisions on multiple governance levels (Beck et al., 2018).
Accountability (D)	The allocation of responsibilities enables participants to identify how and where authority rests and reduces uncertainty for users and other stakeholders operating the network (e.g., accountability for the technical DLT-based platform) (Beck et al., 2018; Liu et al., 2021).
Incentive mechanisms (E)	Key aspects that drive the behavior of entities across the network and platform to enforce the execution of activities necessary for the ongoing operation and governance of the system (Liu et al., 2021).

Table 4-11: Network governance dimensions

Governance in the context of DLT can be characterized as a combination of different functions and constraints in which the future and current use of IT is directed and defined among a group of entities. For example, the way how collective decisions are made (cf. decision control rights, C.1) and how decisions are incorporated (cf. decision management rights, C.2) significantly influence DLT protocol updates (e.g.,

cryptocurrency improvement protocols) and may even lead to a split of the system (e.g., Bitcoin cash hard-fork). Also, ownership and responsibility play a crucial role in affecting a system's governance (cf. accountability, D). For example, a group of known companies in a consortium can be held responsible for downtimes in operating a private permissioned DLT. On the contrary, a public permissionless network based on anonymous nodes (e.g., Bitcoin) may be characterized by limited accountability in the case of system failure. However, a trade-off between centralized and decentralized control must also be considered. As shown in Figure 4-8, the usefulness of a DLT-based platform may increase with the growing number of participating entities in the network, but it can also add complexity (Conway & Garimella, 2020).

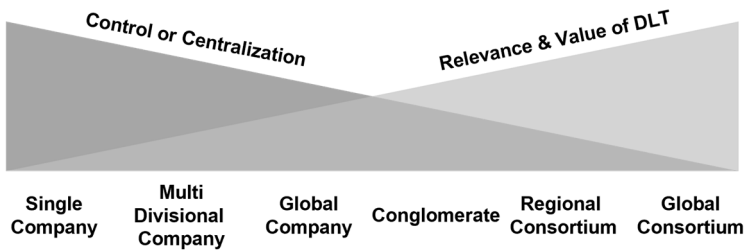


Figure 4-8: Control versus value of DLT (Conway & Garimella, 2020, p. 29)

Following the various entities, additional aspects can be taken into account to influence the participant's behavior on a DLT-based platform (cf. incentive mechanisms, E). Besides known means for incentivization on conventional platforms (e.g., off-chain business agreements, E.2), participants can also be motivated and encouraged through token rewards (on-chain token distribution, E.1). Once a predefined logic for distribution is implemented and specific rules are met, users are autonomously rewarded without the mediation of a third party (i.e., mining). This form of tokenized platform governance (cf. chapter 3.4.3.6) allows, for example, the creation of decentralized marketplaces to empower its users and democratize decision-making. Based on its specific utility, the token is not only externally valuable but can be further used to gain substantial voting rights on the platform (Riasanow et al., 2018).

2nd Level Category	Sub-Categories and Descriptions
Decision rights (C)	<i>Decision control rights (C.1):</i> Formalization of decision-making processes and monitoring of decisions (e.g., initiate change in an orderly and legitimate manner for all stakeholders) (cf. Rauchs et al., 2018, p. 55): • <i>Anarchic:</i> Change requests are provided and approved on a cooperative or voluntary basis, characterized by a lack of authority. • <i>Dictatorship:</i> Decisions on changes are made by one entity (e.g., individual, organization). • <i>Hierarchical:</i> Individuals can propose changes, but according to rank, changes are subject to the approval of the initial leaders. • <i>Federation:</i> A group of entities based on a fixed relationship scheme votes on alterations. Members of a federation do not need to have equal rights or necessarily know each other. • <i>Plutocratic:</i> Change proposals are selected based on voting, where each vote may be weighted according to the importance of each voter. Following plutocracy, a minority of voters is given considerable weight. • <i>Democratic:</i> Proposed changes are selected based on individual votes, with a minority of voters not carrying much weight in their vote.
	<i>Decision management rights (C.2):</i> Creation of decision proposals (e.g., proposal submission) and definition of parameters to propose changes that enable the implementation of decisions (cf. Rauchs et al., 2018, p. 57): • <i>Open:</i> Any entity is allowed to submit changes. • <i>Filtered:</i> Submission of proposals is subject to specific requirements or requires curation (e.g., submission only for token holders). • <i>Authorized alteration:</i> Entities restrict the request for changes (e.g., exclusive membership in industry consortia).
Accountability (D)	<i>Anonymous (D.1):</i> An entity of unknown name and identity remains hidden and acts under a pseudonym (Rauchs et al., 2018, p. 54).
	<i>Individual (D.2):</i> An entity of a known name and identity typically acts as a single person and is distinct from a group.
	<i>Volunteer (D.3):</i> A set of loosely connected entities who collaborate voluntarily and follow no formal structure (Rauchs et al., 2018, p. 54).
	<i>Consortium (D.4):</i> A group of private organizations or public institutions formally collaborate to achieve a common goal (Rauchs et al., 2018, p. 54).
	<i>Foundation (D.5):</i> A non-profit foundation is formally registered under a legal structure and coordinates activities that may follow fiduciary obligations (e.g., Linux Foundation) (Rauchs et al., 2018, p. 54).
	<i>Organization (D.6):</i> A single corporation or a joint venture operates with a designated management function and follows a particular purpose (Rauchs et al., 2018, p. 54).

Incentive mechanisms (E)	<i>On-Chain token distribution (E.1)</i> : Embedded into the DLT protocol, tokens are issued as a reward to users for completing specific tasks or meeting a particular behavior (e.g., mining reward). Tokens may be demanded and valued on their own to incentivize community building or voting on the protocol (e.g., token engineering) (Liu et al., 2021).
	<i>Off-chain business agreements (E.2)</i> : Implicit or explicit contracts external to the DLT system define behavior in the network. Off-chain activities aim to maintain the intended state and purpose of operations carried out on-chain (Beck et al., 2018).
	<i>Other non-monetary (E.3)</i> : Relates to observable non-monetary rewards, such as privileges, visibility, or reputation (Perscheid et al., 2020).

Table 4-12: Sub-categories of network governance dimensions

(III) *Network governance system scope*: For establishing effective governance structures, it is appreciated to follow a systematic approach that reduces the complexity across the various entities and different levels of their interaction (e.g., inter-organizational relationships). Accordingly, five building blocks are identified from a systems perspective in Table 4-13 to specify what to govern in asset tokenization networks.

2nd Level Category	Description
Inter-organizational governance (F)	The focus lies on the stakeholder and their participation based on real-world inter-organizational relationships (e.g., value chain partners) (Labazova, 2019). Decisions made at this layer directly influence the DLT-based platform's rules (e.g., ownership of DLT systems and non-DLT-systems). It also covers institutional governance following all aspects of the network's legitimacy (e.g., institution-based trust). Therefore, the activities should comply with existing laws and policies (e.g., security, privacy, and fairness) (Liu et al., 2021).
IT-System Governance (G)	Governance must be enforced over the IT system built on or integrated with the DLT-infrastructure (e.g., DApps). An effective governance structure supports various application design scenarios. Integrated applications based on DLT components should meet the criteria of established IT governance functions. For instance, regulatory requirements of DLT-based virtual currencies should be considered to prevent criminal activities such as money laundering (Liu et al., 2021).
DLT-System governance (H)	The DLT system follows different rules and mechanisms on a technical platform level with implications for its configuration, system behavior, and infrastructure (e.g., programmable logic, on-chain data storage) (Liu et al., 2021, p. 14). Establishing a set of shared rules and jointly controlling them is key to the operation and scalability of the system.

	On one side, centralized control enables faster development to meet new requirements. On the other side, on-chain operations increase the system's security, trust, and transparency but add complexity.
Consensus mechanism governance (I)	At the most granular level of platform governance, DLT governance deals with the definition of the consensus mechanism (e.g., PoW, PoS, or proof of authority) and the implementation of decision rights and incentive mechanisms codified into the protocol.
Data governance (J)	DLT provides data storage that can raise data privacy and security concerns. Thus, it must be determined which data is stored in which way (e.g., on-chain, off-chain data) and how it is accessed through participating nodes (e.g., permissioned, permissionless system) (Liu et al., 2021, p. 16). Thus, a rule set for the tamper-proof DLT features must be defined that complies with legal frameworks. These principles cover, for instance, the approach to remove records on the shared ledger if needed (e.g., right to be forgotten).

Table 4-13: Network governance system scope

The definitions distinguish key governance areas and identify dependencies for a course of action. *Inter-organizational governance* (F) plays a decisive factor in establishing the platform. By designing the minimum viable solution based on real-world relationships, the founding entities provide the initial structure before developing and scaling the entire platform. *IT-system governance* (G) should be further established in correspondence to the predefined responsibilities of the founding entities. It is suggested that the decision for a particular DLT (e.g., public or private) should depend on the use case and comply with regulatory frameworks (Liu et al., 2021). Therefore the *DLT-system governance* (H) and *consensus mechanism governance* (I) strongly rely on the specifications and parameters of the chosen DLT. Finally, complementing services are taken into account. While DLT enables at its very basis an append-only distributed database, *data governance* (J) should be in place to ensure the quality and security of the data across the network.

4.4.3 Processes

A business strategy is considered successfully implemented once it is fully anchored in the companies' processes (Österle et al., 2011). Accordingly, a process perspective is appreciated to identify the critical activities in value creation and define the business processes for

effective alignment of organizational structures (Österle, 1995). Business models for asset tokenization also imply a processual change that addresses how to create novel services and deliver new offerings. Especially for the financial service sector, the management of asset ownership (e.g., issuance, transfer, and storage of assets) that builds upon DLT-based platforms enables the creation of innovative market infrastructures. For practice, an integrated approach is required to align future business models with existing processes while taking surrounding factors and market requirements into account.

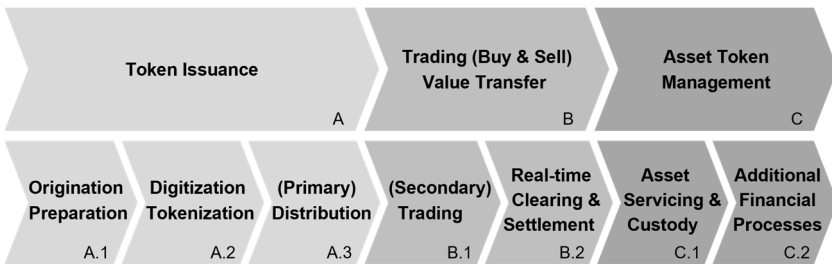


Figure 4-9: Macro and sub-process of asset tokenization

As a result, the process layer defines related activities across the token life-cycle and illustrates the macro and sub-process to describe, analyze, and model subsequent steps for value creation and delivery. Key considerations from the finance domain are taken into account to increase the applicability in practice and provide a useful reference that complies with the general principles of financial market infrastructures (e.g., legal basis, settlement finality) (CPMI, 2014). By referring to a tokenized security in terms of a digital investment product (i.e., security token), three macro steps illustrate the value chain at its most abstract level, shown in Figure 4-9, namely: *token issuance* (A), *trading & value transfer* (B), *asset tokenization management* (C). Following an integrated perspective, this understanding is extended through seven detailed sub-processes (cf. A.1-C2). In combination with the macro (Table 4-14) and sub-level activities (Table 4-15), an economically reasonable structure can be created. Finally, mapping these processes with network roles (Section 4.4.2.1) can further support the identification of core competencies for technical and business-related activities.

Macro Process	Related Activities
Token Issuance (A)	• Selection of a regulatory model for representing assets on DLT-based platforms (e.g., security token, utility token, payment token) • Setup of dependencies between real-world assets and tokens to be issued under legal, business, processual, and technical point of view (e.g., token backed by special purpose vehicle (SPV)) • Security review of token contract code and deployment on chosen platform or infrastructure (e.g., ICO, security token offerings (STO)) • Prepare token for purchase by the token holder (e.g., storage in issuer's technical wallet and initial distribution)
Trading (Buy, Sell) & Value Transfer (B)	• Establish transactions to be recorded on a distributed ledger with tokens to be transferred between seller and buyer • Enabling a digital transfer of ownership without the mediation of one central party • Provide access for the token holder to interact with the tokens and apply them to their exposed function and purpose
Asset Token Management (C)	• Integration of financial service offerings and post tokenization management of asset tokens along their lifecycle • Meeting of additional market requirements of the token holder under consideration of legal and new technical developments

Table 4-14: Macro processes and related activities

Based on an exemplary security token lifecycle, the process starts with the *origination and preparation* (A.1.) to define the general financial setup by specifying the token's liabilities according to regulatory requirements. After preconditions are met (e.g., due diligence, deal structuring), *digitization and tokenization* (A.2) take place. Before the tokens are issued, the relevant technical activities (e.g., smart contract coding) and financial tasks are finalized (e.g., asset valuation and physical safe-keeping). In the third stage, the *primary distribution* (A.3) of tokens to investors is conducted once the platform transaction guidelines are met (e.g., investor onboarding). *Secondary trading* (B.1) on aftermarkets allows the buying and selling of previously issued tokens through additional marketplaces, trading platforms, and exchanges. By using DLT, *real-time clearing & settlement* (B.2) can be performed without mediation. Finally, post tokenization management is ensured through *asset servicing & custody* (C.1) related to the storage of private keys for accessing tokenized assets on the shared ledger. In addition, the

processes are complemented through services covering *additional financial processes* (C.2) (e.g., taxing and accounting).

Macro Process	Sub-process	Related Activities
Token Issuance (A)	Origination & Preparation (A.1)	• Due diligence design and financial deal structuring • Definition of terms & conditions of the token and smart contract backed by the asset to be compliant with regulatory requirements (e.g., DeFi) • Supplier onboarding if issuance requires additional key participants
	Digitization & Tokenization (A.2)	• Asset definition, valuation, and safekeeping • Setup and establishing of SPV • Technology platform selection and smart contract coding • Transfer of transactional information into systems
	(Primary) Distribution (A.3)	• Distribution executed via digital channels • Primary market access is not technically limited but dependent on regulatory requirements • Investor onboarding (i.e., requirements for know-your-customer (KYC), anti-money-laundering (AML)) • Pricing and token distribution to investors
Trading & Value Transfer (B)	(Secondary) Trading (B.1)	• Token holders trade tokens with investors in over-the-counter arrangements or on exchanges • Round-the-clock trading execution is not dependent on trusted institutions due to P2P-based infrastructure • Whitelist management • Increased Liquidity due to P2P-transfer of token
	Real-time Clearing & Settlement (B.2)	• Clearing & settlement do not necessarily require central third parties • Instant exchange of assets enabled through the features of DLT (cf. atomic settlement)
Asset Token Management (C)	Asset Servicing & Custody (C.1)	• Tokens can be stored by trusted third-party custodians or by the token holders themselves using a wallet (e.g., custodial, non-custodial)
	Additional Financial Processes (C.2)	• Dividend distribution • Shareholder Voting • Taxing and accounting • Other financial services (e.g., reporting) • New services (e.g., DeFi)

Table 4-15: Sub-processes and related activities

The presented elements serve as a starting point for structuring relevant activities in DLT-based market structures. It can be argued that many process steps do not significantly differ from the traditional financial value chain. However, new activities will be required that encompass technicalities and address regulatory aspects.

4.4.4 Services

Besides a processual and structural view on asset tokenization, the definition of relevant services extends the understanding of potential market offerings and complements the conceptualization of required capabilities for value creation. Since a common terminology is missing, services can be described *“as the application of competencies for the benefit of another, meaning that service is a kind of action, performance, or promise that’s exchanged for value between provider and client”* (Spohrer et al., 2007, p. 72). Reitbauer et al. (2008, p. 541) consider services *“an additional intermediate layer between the process and systems layers, providing the link between business processes and applications.”* Following a market-oriented view, it can be stated that service design represents an important starting point for strategic and operational decisions that range, for example, from customer-facing activities to an application-oriented composition of IS (Alt et al., 2009).

Based on this understanding, the conceptual model presents a service layer, which defines a set of services, offerings, and products as part of asset tokenization business models. As shown in Figure 4-10, they uniquely define a bundle of economic activities that create value and meet the current market needs of customers within both B2B and B2C markets. The services are grouped into five overarching clusters (cf. I-V), considering their logical, functional, and semantic proximity. The overview serves as a sound basis for conceptualization and analysis to align the general business concept of tokenization with the required capabilities of the provider. Finally, it should be taken into account that the presented services follow current market developments of the tokenization ecosystem and may be subject to change. A separate description of each cluster with its respective services is presented below.

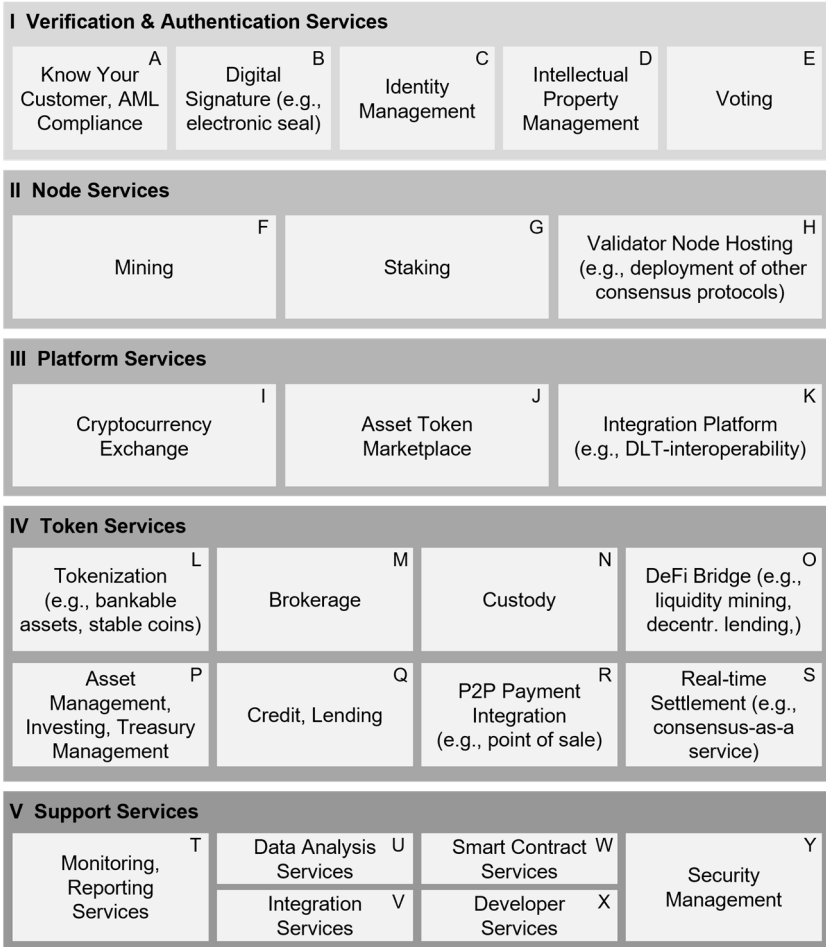


Figure 4-10: Overview of service cluster and service offerings

(I) *Verification and Authentication Services*: The services provide authentication and verification of users, documents, and objects associated with the digital identity lifecycle covering the creation, management, and verification on behalf of clients (Xu et al., 2019). In addition, it includes both services to ensure legal requirements for accessing token platforms (e.g., KYC, AML checks) and solutions that utilize the underlying DLT itself to increase security, efficiency, and transparency in operations (e.g., voting, electronic seals) (Zutshi et al., 2021).

2nd Level Category	Description
KYC, AML Compliance (A)	Verifying user information within an identity layer fulfills the legal requirements to support providers in maintaining KYC and AML compliant procedures (Tasca & Tessone, 2018).
Digital Signature (B)	Hash functions and asymmetric encryption is used for digital signatures. The unique hash is stored on the DLT-infrastructure, where data and transactions are individually certified (J. Zhang et al., 2020).
Identity Management (C)	Identity creation and authentication ensure that providers meet regulatory requirements for a digital identity when establishing and operating token-based platforms (Han et al., 2019).
Intellectual Property Management (D)	A trusted registry based on DLT allows the management of intellectual property rights, media assets, transfer access, and rights information, further covering proof of the existence of an object (Xu et al., 2019).
Voting (E)	DLT-based identity management also ensures the integrity of voting to distinguish between registered and unregistered voters or automate voting procedures (e.g., shareholder voting) (De Rossi et al., 2019).

Table 4-16: Verification and authentication services

(II) *Node Services*: The service provider offers customers participation in transaction validation to engage in the DLT systems' consensus mechanism (cf. public permissionless BC protocols) for token rewards. Depending on specific protocols and consensus algorithms (e.g., mining, staking), the requirements for earning tokens can significantly vary (e.g., provision of computational resources, token lock-in). The provider may also operate nodes individually, implementing only selected protocols on behalf of the customer (Zutshi et al., 2021).

2nd Level Category	Description
Mining (F)	The offering enables the provision of computational resources for transaction validation and ensures the consistency of transactions using DLT. Electricity is required to join the probabilistic, computer-based competition in which participants are incentivized via an algorithmic distribution of token rewards (Alsindi & Lotti, 2021; Xu et al., 2019).
Staking (G)	An alternative offering is to lock some collateral (cf. token) according to the DLT protocol and be rewarded for contributing to the consensus of the distributed ledger proportionally to the staked amount. Staking is considered less computationally intensive to prevent the double-spending of tokens associated with DLT (Alsindi & Lotti, 2021, p. 5).

Validator Node Hosting (H)	Provision of DLT-infrastructure by hosting validator nodes on behalf of customers in addition to selected mining and staking offerings. It enables customers to run a validator node independently, participate in other consensus protocols without restrictions, and delegate resources to earn rewards individually.
----------------------------	---

Table 4-17: Node services

(III) *Platform Services*: The offerings refer to platform-based services that provide customers with a set of functionalities that facilitate the exchange of tokens, payments, and information. Typically based on a modular bundle of various components, firms can further build upon these products to develop complementary services that create value for other market participants (e.g., buyer, seller) (Zutshi et al., 2021).

2nd Level Category	Description
Cryptocurrency Exchange (I)	The platform facilitates the trade and exchange of cryptocurrencies as a subset of DLT-based tokens for conventional fiat money and other cryptoassets. Depending on the level of integration, the core services associated with market making and matching are further complemented by activities from additional service clusters (e.g., custody) (Xu et al., 2019).
Asset Token Marketplace (J)	A platform for trading tokenized assets and other DLT-based tokens streamlines processes for the transfer of asset ownership. It also consolidates various products and services associated with the token lifecycle among various tokenization value chain roles (e.g., issuer, token holder) (Zutshi et al., 2021).
Integration Platform (K)	The platform enables technical integration between two or more DLT-platforms to transfer tokenized assets and seamlessly execute smart contracts across different distributed ledgers (cf. cross-ledger asset transfer). In addition, the integration can enable service bundling to further establish cross-industry and cross-process use cases.

Table 4-18: Platform services

(IV) *Token Services*: The portfolio consists of a wide range of regulated services that directly and indirectly cover the lifecycle and management of tokens or address related use cases based on a DLT-infrastructure. The offerings include novel DLT-enabled services (e.g., custody of public and private keys) and integrated products, which combine aspects of traditional banking with the enhanced potentials of tokenization and

DLT (e.g., Bitcoin payments or cryptocurrency asset management). In addition, financial products that solely derive value from an underlying crypto asset (e.g., Bitcoin certificates) are not included.

2nd Level Category	Description
Tokenization (L)	Offerings to digitize, tokenize, and issue any asset in the form of tokens (e.g., stable coins, NFTs). The services address technical and business-related aspects that range from the valuation for the asset to be tokenized, the digitization using token contract code, integration, and listing on the token platform (e.g., STO) (Lai et al., 2021).
Brokerage (M)	Intermediary services facilitate transactions between market participants and markets, performing actions according to the customers' requirements in return for a fee or a percentage of the transaction volume (e.g., over-the-counter (OTC) crypto trade) (Eickhoff et al., 2017).
Custody (N)	Custody solutions for storing and safekeeping private keys (e.g., wallet) depend on customer needs (cf. custodial, non-custodial) and market requirements (cf. higher availability using hot wallets, higher security using cold wallets) (Bear et al., 2020).
DeFi Bridge (O)	Services provide regulated access to a portfolio of different DeFi protocols that replicate existing financial services based on tokens (e.g., lending and borrowing, creating and trading of derivatives) in a more open, interoperable, and transparent way. These applications often relate to an incentivized provision of collateral and liquidity using cryptocurrencies (cf. yield farming) of users on decentralized markets, which do not rely on intermediaries and centralized institutions (e.g., Uniswap as a decentralized exchange (cf. DEX)) (Schär, 2021).
Asset Management, Investing, Treasury Management (P)	Offerings support the management of tokenized assets during their lifecycle on behalf of customers to increase value and decrease investment risks over time. To acquire, maintain, and trade tokens effectively, market know-how and activities similar to conventional asset classes are required (e.g., stocks, real estate) (Reitbauer et al., 2008). Activities may be extended through treasury management to effectively allocate the enterprise's holdings, liquidity, and operational risks.
Credit, Lending (Q)	Services enable liquidity increase via loans granted against a pledge of tokenized assets (cf. Lombard loans), typically cryptocurrencies (e.g., Ethereum). Besides lending, customers may also enter credit contracts as a borrower.
P2P Payment Integration (R)	Solutions enable merchants to accept tokenized assets and cryptocurrency transactions by integrating DLT-based P2P transactions into traditional payment systems using fiat currency for a faster and seamless customer experience (e.g., point of sale) (Zutshi et al., 2021).

Real-time Settlement (S)	Services provide a settlement layer for individual customer applications utilizing immutable and verifiable logs of messages on a distributed ledger to establish a single source of truth between accounts in real-time (e.g., consensus). As a foundation for trustless execution and dispute resolution between organizations (e.g., trade finance), the distribution of sensitive data is often ensured through private permissioned DLTs (e.g., R3 Corda, Hyperledger Fabric) (Schär, 2021).
--------------------------	---

Table 4-19: Token services

(V) *Support Services*: The offerings refer to ancillary and value-added services and describe practices that support core processes and indirectly contribute to value creation. The activities typically generate value for customers combined with other services to facilitate, promote, and extend their functionality and scope (Alt et al., 2009).

2nd Level Category	Description
Monitoring, Reporting Services (T)	Support services are associated with auditing and measuring the overall system's performance, where a systematic approach allows one to take action once problems and anomalies occur (X. Li et al., 2021).
Data Analysis Services (U)	Activities for collecting and analyzing transactional data of DLT-systems to interpret patterns, visualize information, enhance transparency, and create meaningful insights for different stakeholders. (X. Li et al., 2021).
Integration Services (V)	Practices support the administration of system components and management of application programming interfaces to integrate new or maintain existing components for seamless interaction between systems (Zheng et al., 2019).
Smart Contract Services (W)	Activities support developers to design, implement, and operate applications running on self-executing smart contracts. The activities involve procedures and workflows ranging from DLT-protocol configuration, testing, and DApp deployment (Zheng et al., 2019).
Developer Services (X)	Support services facilitate IT-systems engineering by providing tools (e.g., IDE, SDK) and best practices for a user-centered application design on top of DLT-systems (Zheng et al., 2019).
Security Management (Y)	Activities focus on identifying, developing, and implementing relevant security policies and procedures to protect systems and other assets from threats and vulnerabilities regarding security attributes such as authentication, authorization, confidentiality, integrity, and accessibility.

Table 4-20: Support services

4.4.5 Technology

The issuance, transfer, and storage of tokens on DLT-based platforms build upon shared IS (cf. decentralized IS), jointly managed and operated within the asset tokenization network. To support these inter-organizational business processes efficiently, the execution of IS depends further on its underlying architecture (Haki & Forte, 2010). Following Baldwin & Woodard (2008), the architecture structures complex issues highlighting components and relationships of a system to be modeled. More specifically, it supports a logical design of IS on the systems layer by taking the relevant strategic and processual decisions into account (Alt, 2008). In the context of asset tokenization, various architectures for DLT-based platforms and applications exist. They consist of multiple components and layers, where each layer can be further structured into sub-components (Rauchs et al., 2018). While practitioners face numerous architectural design decisions, an overview is appreciated that provides a common understanding of this complex system and summarizes the characteristics of potential implementations.

As a result, the technology layer of the conceptual model outlines a generic DLT-based architecture for asset tokenization, its system components, and functional relationships. As shown in Figure 4-11, it is divided into seven complementary elements (cf. I-VII), providing a conceptual foundation for an integrated IS with several building blocks and design options (cf. A-T). Each element highlights architectural considerations that relate to various aspects ranging from software components (e.g., API layer) to the DLT system (e.g., DLT protocol layer), infrastructure (e.g., physical layer), and system-related requirements (i.e., security, governance, and compliance). The overview provides an understanding of characteristics and trade-offs between various DLT designs (e.g., Ethereum, Corda) by introducing additional design options (e.g., access, validation). Based on potential configurations, a setup for applications is iteratively established that illustrates a set of appropriate design choices to understand how different features shape a specific solution. A Turing complete *programmable logic* (H) in smart contract code, for instance, is appreciated for the flexible creation of

Applications for asset tokenization (e.g., wallet for tokens) build upon integrated system components that do not operate in isolation but rather require DLT and non-DLT functionalities based on various IT resources (e.g., hardware for cryptocurrency mining). The interaction with external systems with an *API layer* (II) is necessary to trigger events or reference objects outside the DLT system (e.g., track and trace). These gateways to the outside world rely on external agents (i.e., oracles) using existing legal structures to justify decision-making (Rauchs et al., 2018, p. 12). As described below, the elements are arranged hierarchically and build on each other. They are further divided into sub-categories and focus not on an entirely technical but functional categorization.

(I) *Application Layer*: As the first part of the architecture, the layer provides user-facing applications or aggregates different applications to access the platform. It builds on the functionalities of the underlying layers and relies on resources and infrastructure to connect to the DLT. The interaction with DLT functions (e.g., smart contracts) requires different interfaces (cf. GUI, A), typically a web browser-based frontend (Schär, 2021). The *user* (B) and *administrator applications* (C) can be written in different front-end languages to make API calls to the backend that operates on a decentralized computing system (cf. DLT) or even include on-chain logic for fully decentralized applications (DApps, D) (cf. smart contract code executed by DLT) (Mazzei et al., 2020).

2nd Level Category	Description
GUI (A)	A graphics-based interface enables human-computer interactions with different devices, typically a web browser-based front end.
User Applications (B)	Applications for users serve as clients to communicate with the DLT. They are designed individually and carry out tasks that do not rely on on-chain execution or business logic (cf. smart contracts).
Administrator Applications (C)	Applications for administrators serve as clients to communicate with the DLT. They are designed individually and carry out tasks with full privileges, not relying on on-chain execution or business logic.
DApps (D)	Applications combine both off-chain and on-chain logic to provide main functions through smart contracts. The core programming logic is executed on a decentralized computing system (Xu et al., 2019).

Table 4-21: Application layer

(II) *API Layer*: As a type of software interface, the layer serves as a connecting layer between the DLT, other non-DLT components, and applications external to the system. It ensures efficient and reliable communication (e.g., transaction exchange) through standardized API calls of DLT-functions and enables access to external computational resources and data (Abreu et al., 2020).

2nd Level Category	Description
External API (E)	External interfaces allow communication with components outside the system (e.g., external applications, other DLTs) to access data, functions, or other computational resources (cf. off-chain services).
User API (F)	Efficient access for user applications is established to call DLT-specific functions to perform a predefined task or enable communication to on-chain and off-chain data.
Administrator API (G)	Efficient access for administrator applications is established to call DLT-specific functions to perform admin and operator tasks or enable communication to on-chain and off-chain data.

Table 4-22: API layer

(III) *DLT Protocol Layer*: The first of the three main DLT layers refers to its underlying protocol and defines the main functionality of how the DLT-system operates. Following Rauchs et al. (2018, p. 34), the protocol can be described as “a set of constitutional arrangements agreed upon by all system participants.” It determines the abilities (cf. programmable logic, H), the formal ruleset (cf. consensus mechanism, I), and the design (cf. codebase, J) of the DLT and runs across its network nodes based on the hardware and infrastructure provided.

2nd Level Category	Description
Programmable Logic (H)	The functionality describes the handling of business logic to be categorized into <i>none</i> (inability to handle business logic), <i>scripted</i> (support of built-in predefined events), and <i>smart contracts</i> (custom event handling and processing of any business logic provided) (Plazibat, 2019).
Consensus Mechanism (I)	The algorithm defines how system participants (i.e., nodes) agree to synchronize and maintain consistency within the distributed ledger. Besides <i>PoW</i> and <i>PoS</i> , various alternatives exist to validate transactions without a centralized instance (e.g., Corda notary nodes).

Codebase (J)	The setup of the codebase repository defines the foundation of the DLT and specifies the development activities of its protocol, whether following an existing <i>open-source</i> platform or a <i>closed-source</i> redevelopment (Rauchs et al., 2018).
--------------	---

Table 4-23: DLT protocol layer

(IV) *DLT Network Layer*: The second DLT-specific layer addresses the interconnected technical roles (i.e., nodes) defining the abilities to store and propagate data within the network. In particular, the layer determines which nodes can read (cf. access, K) and update transactions (cf. validation, L). It also defines how the global state of the ledger is perceived after the transaction is completed, as *deterministic* or *probabilistic* (cf. transaction finality, M) (Rauchs et al., 2018, p. 35). In general, the network layer follows the codified rule set of the protocol layer and describes how nodes communicate, thus providing the basis for trustless execution and settlement (Schär, 2021).

2nd Level Category	Description
Access (K)	The characteristic refers to accessibility and the way communication is established between network nodes. <i>Private</i> describes limited reading capabilities, where only authorized participants can access the network. <i>Public</i> enables every participant to access data through open network protocols (Plazibat, 2019). The combination of private and public leads to <i>hybrid</i> access as data is shared openly between organizations and managed by pre-defined nodes (Labazova et al., 2018).
Validation (L)	Analogous to network access, the characteristic describes the ability to send, receive, and validate transactional data. <i>Permissioned</i> refers to authorized participants who can add transactional data to the system. On the contrary, <i>permissionless</i> allows non-authorized participants to validate transactions (Labazova et al., 2018; Plazibat, 2019).
Transaction Finality (M)	The ability refers to the perceived system state of replicated transactional data in the network to be defined as <i>final</i> (i.e., deterministic) or <i>probabilistic</i> . Once confirmed, a deterministic finality of transactions instantly leads to tamper-proof data. Based on a probabilistic finality, the possibility for manipulation only decreases over time. For Bitcoin, every additional confirmed block added to the BC increases the probability that data cannot be altered. (Rauchs et al., 2018, p. 63).

Table 4-24: DLT network layer

(V) *DLT Data Layer*: At the core of DLT functionality, the layer outlines four primary architectural considerations to define *what data sources are used* (N), *where required data is stored* (O), *how transactions are structured* (P) and *how it is replicated across the network* (Q). The layer represents a basis for the information flows between participating nodes and leads to significant implications for the overall design and functioning of the system (e.g., performance, security) (Che et al., 2019).

2nd Level Category	Description
Data Sources (N)	The method specifies how the DLT relies on data for the execution of tasks ranging from <i>internal</i> data sources held in the distributed ledger itself (e.g., transactional data), <i>external</i> data sources (e.g., oracles), or <i>hybrid</i> as a combination of both internal and external (e.g., state channels) (Rauchs et al., 2018, p. 66).
Data Storage (O)	This consideration defines where to store data within the system. While meta-data is often stored <i>on-chain</i> (e.g., timestamps, hashes), raw reference data is typically stored <i>off-chain</i> (cf. content addressing) to improve the storage capabilities, confidentiality, and performance within a shared infrastructure (e.g., IPFS) (Xu et al., 2017).
Data Concept (P)	The concept describes how transactional data is stored and structured. Well-known concepts are <i>blockchains</i> or <i>directed acyclic graphs</i> (DAG). BC contains cryptographically sealed transactions forming a chain of blocks replicated across all nodes. DAG relies on single transactions linked together through graphs maintained only by specific nodes (Kannengießer, Lins, Dehling, et al., 2020; Plazibat, 2019).
Data Broadcast (Q)	The process specifies the transmission of data across the network and its participating nodes (Rauchs et al., 2018, p. 59). In a <i>globally replicated</i> DLT, the network broadcasts transactional data across all nodes sharing identical records (e.g., Ethereum). <i>Locally replicated</i> refers to a shared subset of records broadcasted to selected and trustworthy nodes on a need-to-know basis (e.g., Corda).

Table 4-25: DLT data layer

(VI) *Physical Layer*: The layer represents an extension of the DLT-based architecture describing a range of different IoT devices transmitting data to the DLT. Information is gathered, for example, through *sensors* (S) or *Auto-ID* (R) using near-field communication (NFC) and tags embedded into physical items. Once tamper-resistant and shared transactions are automatically executed through DLT, *actuators* (T) convert

the incoming signals into movement (Latif et al., 2021). In such smart environments, the physical and digital world converge to increasingly expand the opportunities for value creation in a token economy.

2nd Level Category	Description
Auto-ID (R)	The technology refers to identification systems used for automated retrieval of data of an object transmitted to a DLT system without human involvement (e.g., NFC, optical character recognition (OCR)) (McFarlane et al., 2003).
Sensors (S)	Devices enable data collection and pre-processing of temperature, humidity, pressure, weight, and geo-location for transmission to the DLT system (Latif et al., 2021).
Actuators (T)	Devices create motion due to receiving control signals from the DLT-system representing, for example, motors, valves, or robotic manipulators (Latif et al., 2021).

Table 4-26: Physical layer

(VII) *Security, Governance, and Compliance*: Following a cross-functional perspective, the layer bundles several system-related activities to align with security, governance, and compliance requirements. Especially for decentralized IS, practices are appreciated to follow a systematic approach and ensure the integrity of system components and participating roles across all functional layers. Different principles and policies may apply to specific industries (e.g., financial services sector) and use cases (e.g., identity management) with emphasis assigned to specific areas and components of the system (cf. Network governance system scope). Nodes, for example, may require authentication to be held accountable in case of downtimes or failure. In addition, confidentiality will be needed for applications using sensitive transactional data, such as payments or health. Also, authentication and access control might be required between the different network participants. While security-oriented tasks focus primarily on technicalities to ensure the proper functioning of systems (e.g., data encryption, code review), governance and compliance-related activities must conform with policy, standards, and laws across all organizational levels.

4.4.6 Environment

Technology has infused day-to-day life in the form of innovative products and smart services for individuals, businesses, and society in general. In this uncertain, competitive, and volatile environment, organizations must respond to changing customer behavior by identifying business opportunities and adopting new technologies in line with current market developments (Henriette et al., 2016). However, there is no one-size-fits-all approach for making business decisions in such complex environments. Especially for disruptive technologies, such as DLT, and innovative services around asset tokenization, it is appreciated to build up know-how and constantly anticipate external risks.



Figure 4-12: Overview of the environment

Therefore, as the basis of the conceptual model, the environmental layer is introduced to consider the external context and capture outside factors that affect the design and development of asset tokenization business models and services (Notheisen et al., 2017). As shown in Figure 4-12, the layer describes four environmental areas that might

either prevent or encourage a successful adoption: *regulation* (I), *legal* (II), *standardization* (III), and *socio-economics* (IV). The degree of innovation and the implications of DLT on both processes and structures lead to several challenges. The joint operation of DLT relies on external participants (e.g., users, nodes, consortia), where decentralized decision-making outside the system requires new legal structures. Trustworthy gateways will be needed in the future, as legislation should always follow a technology-neutral approach. In addition to legal developments, companies may further engage in standardization to accelerate adoption through the latest industry guidelines. Socio-economic factors can directly influence the business activities for commercialization and should also be considered. The abstract elements are further summarized below, as legal aspects typically constrain a conceptualization and should be specified in the first place.

(I) *Regulation*: The factor describes legal considerations and rules created by governmental agencies, known as regulators (e.g., FINMA, BaFin), to regulate private sector market behavior (Khemani & Shapiro, 1993). *Regulated* (A) markets protect the public interest, where various regulations for asset tokenization can apply from a technical and business-oriented perspective. Especially for the financial services sector, transferring asset tokens on decentralized platforms requires compliance with existing securities regulations (Allen et al., 2020). The requirements often rely on a centralized paradigm and are usually not adapted yet to consider the implications of decentralized structures and innovations. National legislations can enormously differ, where the same product in *unregulated* (B) markets is not subject to any regulation or interventions (Labazova, 2019).

(II) *Legal*: The factor describes the legislation to be enforced by institutions and applied by participating roles in the asset tokenization network to comply with legally binding rights and decide how disputes are resolved (e.g., contractual claims). *Private law* (C) provides the basis for private concerns. It addresses liabilities in contracts and defines, for example, if codified agreements executed by DLT are legally enforceable (cf. legally binding smart contract). For *public law* (D) that represents

relations between the state and its citizens, an additional focus may lie on administrative (e.g., tax-related aspects for new asset classes) and criminal laws (e.g., money-laundering) (Salmon & Myers, 2019). *Data protection* (E) refers to a broad set of principles to ensure, for example, the accountability of decentralized data processing, the protection of sensitive on-chain data, and the integrity of privacy rights for replicated and tamper-proof records (e.g., right to be forgotten) (Millard, 2018).

(III) *Standardization*: Various principles improve and ensure the development, safety, interoperability, and compatibility of products associated with asset tokenization and its underlying DLT based on industry experience and collaboration of relevant actors (e.g., companies, interest groups, standards organizations) (Xie et al., 2016). Standardization can accelerate the adoption of innovations leading to recognized industry *standards* (G) (cf. ISO/TC 307⁹). These can relate to various technical and processual guidelines, such as cross-industry interoperability between different DLTs using standardized API and data. In a broader sense, the term also refers to best practices (F) as a proven technique and best-known method to accomplish certain objectives. These practices can cover a variety of disciplines to optimize, for example, the efficiency and effectiveness of DLT-projects or software engineering.

(IV) *Socio-economics*: The combination of social and economic factors also involves political, demographic, and ecological processes that directly influence companies' decision-making and business activities. In line with value creation and service delivery, a focus lies on *sustainability* (H) and *education* (I). The impact of sustainability on investments is a driving factor for offering specific services and issuing tokens for specific assets. The role of environmentally friendly consensus protocols, for example, may further increase to shift from energy-intensive (e.g., PoW) to more resource-efficient algorithms (e.g., PoS). In addition, education is of growing interest to the asset tokenization ecosystem. On the one hand, it refers to developing the required skillsets for highly demanded positions (e.g., war for talents). On the other hand, it fosters an

⁹ refers to the technical committee (TC) 307 of the International Organization for Standardization (ISO), which is to publish a standard for blockchain and distributed ledger technologies (www.iso.org).

understanding of the technology and its business potential for various stakeholders, including future customers.

4.5 Practical Application

Based on the artifact and its respective elements, the following sections present two application scenarios conducted in an organizational setting. In further meetings (cf. L, M, Appendix E.2), the practitioners were able to design a conceptual value architecture for their company specific-asset tokenization business models. For comparability within the two participatory case studies, a structured approach for the various elements of the artifact was introduced. Figure 4-13 highlights the simplified top-down approach with five basic steps following the idea of strategic service design by Alt et al. (2009, p. 110).

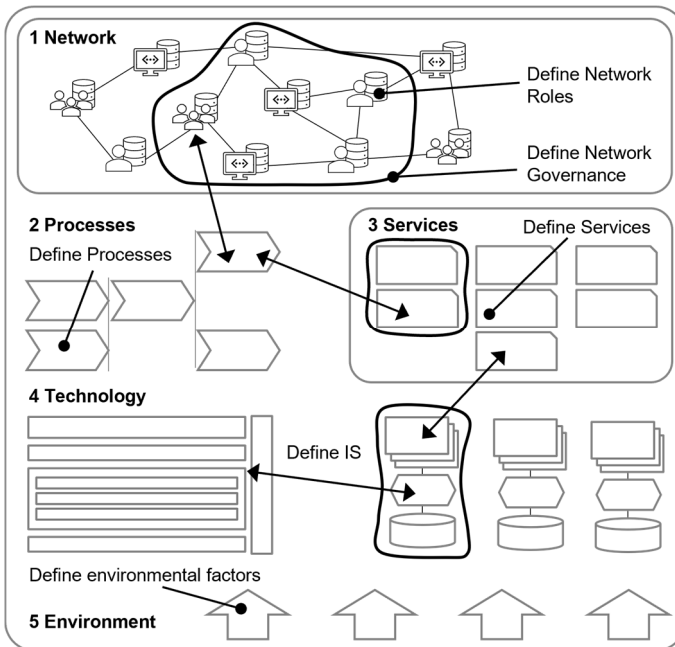


Figure 4-13: Simplified application of the conceptual model

At first, the respective roles were defined and briefly visualized with their network relationships. Here, it can be stated that one entity can also

take on multiple roles. If applicable, the view on governance was further specified. A mapping between the tokenization sub-processes and network participants was conducted as a second step. After illustrating the related activities and responsibilities, existing and future services were identified. As the main source of revenue, the focus was primarily on offerings for end customers. In a fourth step, the description of the technology layer served as a first basis for understanding the required business services for the underlying IS. However, more established approaches are needed to specify the application architectures of the system. Lastly, environmental factors were identified and summarized. The preliminary results of the meetings were complemented with secondary data (e.g., company's website, press reports), additionally refined, and finalized via email communication.

The main goal of this chapter is to *“demonstrate the use of the artifact to solve one or more instances of the problem”* (Peffer et al., 2007, p. 13). In this context, the two case studies serve primarily as an exemplary basis for demonstration in practice. The results are partially adapted and anonymized for confidentiality reasons and may not reflect the current business strategy of the two participating companies.

4.5.1 The Case of BEKB

BEKB operates the DLT-based trading platform *SME-X*, a digital marketplace for tokenized unlisted securities of Swiss SMEs. Based on the Swiss legal framework for ledger-based securities¹⁰ (i.e., register uncertificated securities), the shares are issued, transferred, and stored in the form of asset tokens. The fully regulated platform was collaboratively developed with *daura* and *Hypothekarbank Lenzburg* in cooperation with additional partners (e.g., Taurus) and enables new process improvements (e.g., instant-settlement, automated management of shareholder register) and innovative market opportunities.

¹⁰ The legal framework regulates the transfer of rights on a distributed ledger using a digital register and introduces a new category of ledger-based securities (Registerwertrecht) in the code of obligations (Obligationenrecht OR art. 622, para. 1; art. 973d.) (cf. BBl, 2020)

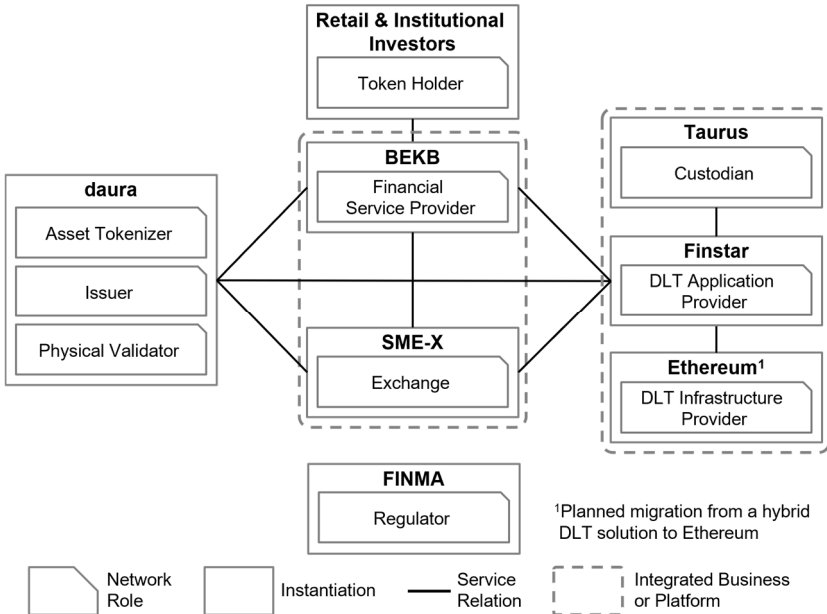


Figure 4-14: Adapted network roles for the case of BEKB

The various roles are adapted to *BEKB*'s business model and highlighted with their simplified interrelationships in Figure 4-14. Apart from the *regulator* and the *token holder*, the tokenization value chain operates primarily on the *Ethereum* BC and consists of five key participants: the *SME-X* trading platform, *BEKB*, *daura*, *Taurus*, and the *Hypothebank Lenzburg* (HBL) with its core banking system *Finstar*.

With a focus on customer relations, *BEKB* provides access to investors and potential SMEs for listing their securities in the form of tokens. Together with *daura*, the digitalization of shares is enabled. The fintech takes on multiple roles and serves as *asset tokenizer*, *issuer*, and ensures the linkage between the on-chain and the off-chain world (i.e., physical validator). The trading is conducted through *SME-X*, acting as a centralized *exchange*. The technical infrastructure is supported through the open banking platform *Finstar*. Cash settlement is performed within *BEKB*'s banking system, as stable coins or tokenized currencies (cf. CBDC) are not yet considered. *Finstar*, respectively HBL, is

technically safekeeping the digital assets using the integrated custody solution of *Taurus*. However, the management of cryptographic keys is also ensured by BEKB. Currently operating a hybrid solution with *daura's* platform using *Hyperledger*, tokens are additionally issued based on *Ethereum's* ERC-20 token contract. DLT-based technical roles (Table 4-8) and DLT-based system roles (Table 4-9) exist but are not further specified in this case study.

The coordination of the digital asset ecosystem relies mainly on off-chain mechanisms based on defined business agreements and centralized accountability. For the system interaction, DLT and smart contracts offer a trust-building element. During the transfer of ownership, the pre-defined token transaction logic is executed, leading to a single source of truth for all parties involved.

BEKB	Origination Preparation				Additional Financial Processes
daura	Origination Preparation	Digitization Tokenization			
SME-X			Primary Distribution	Secondary Trading	
Finstar				Real-time Clearing & Settlement ¹	
Ethereum				Real-time Clearing & Settlement	
Taurus				Asset Servicing & Custody ²	

¹Off-chain system integration ²Management of cryptographic keys by BEKB

Figure 4-15: BEKB sub-processes for asset tokenization

As shown in Figure 4-15, a mapping between the roles and the tokenization process was further conducted. *BEKB* and *daura* are primarily responsible for meeting the business-oriented and technical requirements during token issuance. After the conditions for listing the SME on the platform are met, the tokenization of the shares takes place. Once

the investors are onboarded, whitelisting and primary distribution on the *SME-X* are initiated. Transactions are instantly settled through the Ethereum-based infrastructure. The smart contracts automatically trigger an entry in the shareholder register, allowing investors to enforce their rights directly. Combined with off-chain systems (e.g., Finstar core banking systems), the platform eliminates the need for portfolio reconciliation, improving settlement times by two days. For the token holder, the assets are assigned to a conventional securities deposit account provided by *BEKB* (cf. cryptographic key management) and technically stored on customers' behalf via the Taurus custody solution.

Regarding the service portfolio (Figure 4-16), the platform covers the entire process chain of an asset token marketplace from issuance to custody and trading of tokenized assets. *BEKB* customers can trade tokens via traditional channels (e.g., e-banking, customer advisor), complementing *BEKB*s conventional brokerage with investment products of the *SME-X* exchange. A strong focus lies on process improvements and the possibility of offering a wide range of additional asset tokens (e.g., art, real estate) soon. Instant settlement and DLT-based processes add value. While investors directly invest in companies quickly and cost-effectively, the tokenization service supports SMEs that seek a fast and secure way to issue shares without manual processing and administration (e.g., updating the shareholder register).

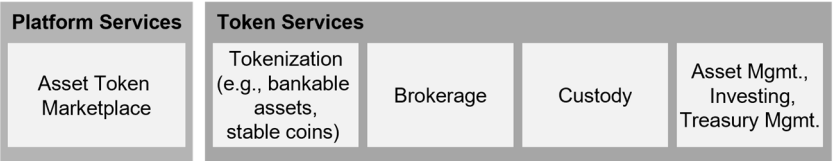


Figure 4-16: *BEKB* services and service cluster

The technical platform currently builds upon a hybrid solution to issue asset tokens via the Ethereum BC using the smart contract language Solidity and the ERC-20 token standard. While Ethereum can be categorized as an open-source, public permissionless DLT (Section 2.1.4), the architecture of the IT system consists of both on-chain and off-chain components to create synergies between the features of centralized

and decentralized IS. The *SME-X* trading platform is fully developed and operated by *BEKB* in collaboration with its partners. Sensitive information is held off-chain to ensure confidentiality, authenticity, integrity, and non-repudiation where needed. Finstar's core banking system and Taurus digital asset solutions also enable a seamless integration of other tokenized assets into the *SME-X* platform. Depending on the use case, its unified APIs cover various DLTs, including public (e.g., Ethereum) and private systems (e.g., Hyperledger).

Besides technical developments, *BEKB* is committed to the training and education of its employees and is building up further knowledge about digital assets and cryptocurrencies. Also, the cooperation with other financial services providers is appreciated to benefit from network effects and extend market infrastructures. In doing so, it is always essential to provide customers with a fully compliant offering. *BEKB* and especially *daura* are working closely with legal experts in this area (e.g., *MME Legal AG*) to comply with regulations and cover new legislation. Standardization also plays a crucial role, as industry standards are slowly emerging to facilitate new end-to-end use cases for tokenization.

4.5.2 The Case of NYALA

NYALA enables the transformation of the financial industry through decentralized technologies, providing a range of technical and financial solutions across the issuance, trading, and custody of digital assets and cryptocurrencies. Under the German Electronic Securities Act¹¹ (i.e., *eWpG*), *NYALA* can process fully electronic securities based on a licensed cryptocurrency registry operated with additional partners (e.g., *Smart Registry*). Regarding these services, the fintech successfully collaborates with the investment platform *Invesdor* to issue fully digital bearer bonds of SMEs using the *Stellar BC*. In addition to optimized client onboarding (e.g., *KYC* and *AML* verifications), the investment

¹¹ The Act regulates the issuance of securities (i.e., bearer bonds) as fully electronic securities. In practice, crypto securities as a subset are applied and managed in a crypto securities register (*Kryptowertpapierregister*), where the technical requirements being met by DLT (BGBl, 2021).

platform benefits from automated register management, streamlined transaction processing, and secure data exchange.

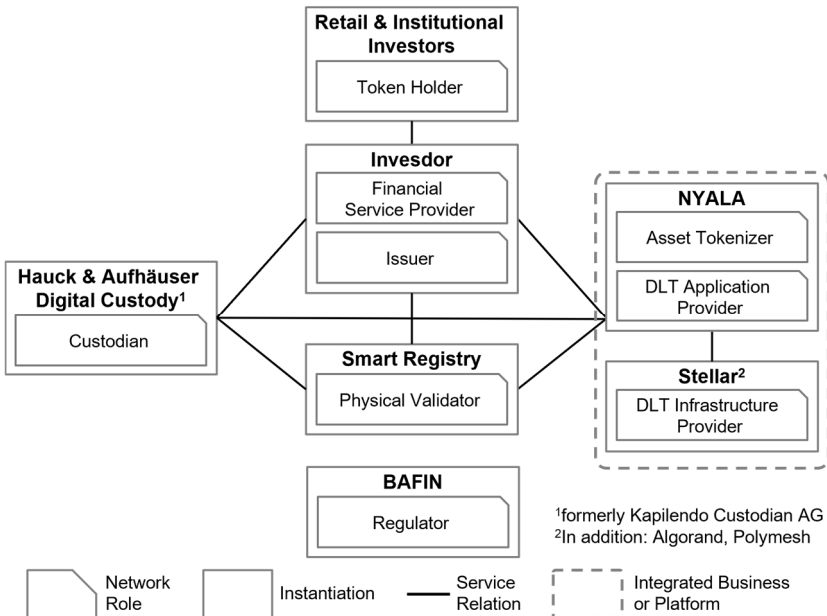
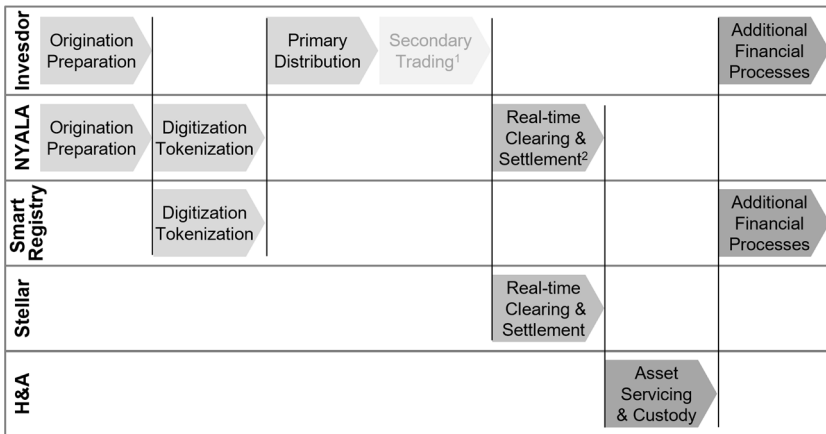


Figure 4-17: Adapted network roles for the case of NYALA

Besides the regulator and token holders, the business network consists of four key organizations: *NYALA*, *Invesdor*, *Smart Registry*, and *Hauck & Aufhäuser*, utilizing the *Stellar* BC for the issuance of digital bonds (Figure 4-17). *Invesdor* is a financial services provider and enables SMEs to raise capital through retail and institutional investors. The company also initiates all pre-issuance activities directly with the SMEs to list crypto securities as regulated investment products on its platform in exchange for funding. *NYALA* acts as the technology provider and offers a regulatory service primarily by creating asset tokens and relevant entries for the crypto securities register. Herefore, it is also performing due diligence, mainly for AML purposes. Although the management of asset ownership is technically distributed, the eWpG act requires a so-called norm addressee to maintain the crypto securities register. Accordingly, the *Smart Registry* is subject to legal obligations and ensures

enforceability between the on-chain and off-chain world (i.e., physical validator). In addition, *Hauck & Aufhäuser* holds the crypto custody license issued by the *Bafin* and complements the primary market infrastructure storing the cryptographic keys on behalf of its clients.

Currently, the strategic interaction between the organizations builds upon off-chain governance mechanisms and bilateral business agreements. The infrastructure increases security and transparency among the various institutions involved via the distributed registry. Reduced costs for SMEs and investors are one of the main drivers to integrate the DLT-based infrastructure into *Invesdor's* investment platform.



¹Planned ²Off-chain system integration

Figure 4-18: NYALA sub-processes for asset tokenization

The asset tokenization process in Figure 4-18 is initiated by *Invesdor*, who is responsible for the acquisition and onboarding of the SMEs to be listed. The definition of the regulatory terms of the token and the smart contract to be backed by the SME's bearer bond is done in collaboration with *NYALA*. Digitalization and tokenization take place in the next step, where the fintech creates a digital asset on the *Stellar* BC to represent the security. With the *Smart Registry*, transactional information is initially transferred into the system. The digital assets are then prepared for purchase by the token holder (e.g., storage in the issuer's

wallet for initial distribution), listed, and distributed via digital channels on *Invesdor*'s investment platform. Based on the *Stellar* BC, the global crypto securities register automatically notifies counterparties of pending payments or new trades and adds corresponding transactions in real-time. Finally, the token holder can directly access purchased digital assets and other services through their accounts at *Invesdor* with the cryptographic keys stored by *Hauck & Aufhäuser* (H&A).

As a provider of both technical and financial solutions, *NYALA* offers a wide range of products for institutional clients and financial services beyond the mere tokenization of bearer bonds. The service portfolio covers the whole lifecycle of asset tokenization and is complemented by compliant solutions for cryptoasset servicing (Figure 4-19).

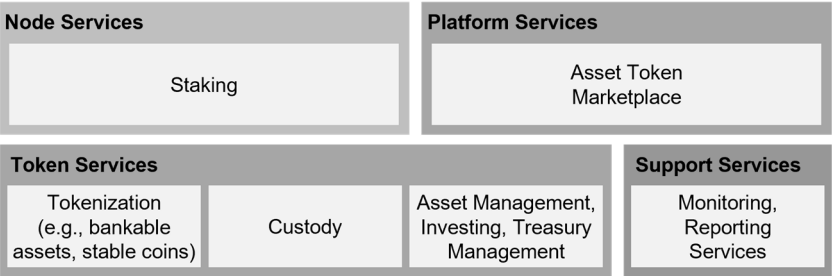


Figure 4-19: NYALA services and service cluster

Commercial clients (e.g., banks) can issue fully digital securities using a DLT protocol of choice (cf. tokenization). In combination with a setup of wallets and required registrar services (cf. supports services), fully compliant asset marketplaces can be established. *NYALA*'s distinct custody in cooperation with *H&A* further facilitates access to crypto-assets (i.e., tokens, cryptocurrencies) via securely stored cryptographic keys. Customers may also invest in cryptocurrencies via the integration of exchanges and earn interest in participating in the network consensus of various public BC protocols (cf. staking).

The *NYALA* digital asset platform builds upon several API platform services. Apart from integration and staking of cryptocurrencies, the presented case of tokenized bearer bonds relies primarily on *NYALA*'s

issuance and custody capabilities using the Stellar BC. The components are shown in Figure 4-20, where the clients can access the portal via a web application. However, business users (e.g., admin) may integrate the services into their system landscape via an external API.

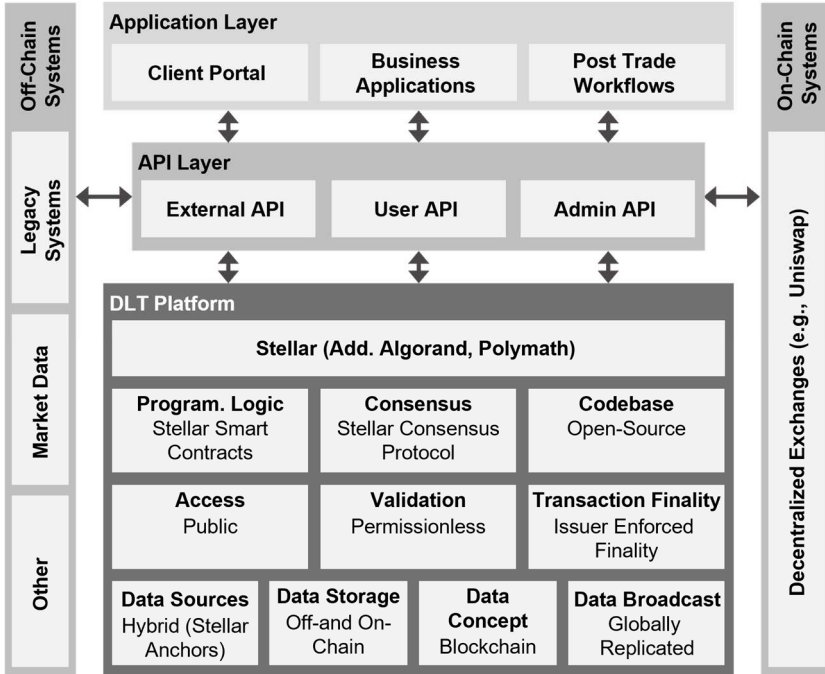


Figure 4-20: NYALA technology layer

For handling pre-and post-processing of the involved participants (e.g., order matching, post-trade workflows), additional business logic is implemented into the architecture. The connection to the DLT platform is ensured via DLT-adapter to communicate with the nodes, send signed transactions, query meta-data, or listen to events (i.e., event handler). The Stellar BC is classified as an open-source public permissionless DLT. Compared to Ethereum, the Stellar consensus protocol enables higher transaction throughput, low-cost fees, and transaction finality. The assets are tokenized using *Stellar Assets* issued by *Anchors*¹² in

¹² Any organization (e.g., banks) or individual can issue assets in using IOUs («I owe you»: Acknowledgment of debt) once the involved parties trust the issuer of the asset and its ability to enforce IOUs

the network. Third-party providers and market data services are further connected via external services components. However, other pricing mechanisms will be integrated using on-chain systems from a DEX in the future.

In terms of external factors and developments, *NYALA* will continue to address the growing demand for cryptocurrencies by institutional clients (e.g., family offices) through its crypto-as-a-service and investment solutions. As the adoption of asset tokenization will grow, the fintech currently sees potential for decentralized technologies in specific market segments (e.g., OTC trading) or dedicated DLT-based services (e.g., shareholder voting). However, the volume for tokenized assets needs to increase significantly to motivate established players to move to DLT-based market infrastructures fully. Once a viable ecosystem is established and more processes are executed on-chain, asset tokenization will reach its full potential.

4.5.3 Analysis and Implications

The case studies and workshops with practitioners provided insights into how asset tokenization changes existing processes and structures. Especially for tokenized securities, the experts highlighted the advantages of significantly improving today's trading, clearing, and settlement processes. However, challenges to establishing such innovative business models still exist. In the following, these insights are summarized to outline the practical implications of asset tokenization and take a closer look at the future transformation of existing financial market infrastructures.

- While competition and cooperation play a vital role in a successful setup of asset tokenization business models, the participants must explicitly define the shared governance mechanisms, rules, and processes for establishing the DLT-based platform and respective structures. As a result, it often takes an initial sponsor to overcome resistance and join the network.

- On-chain governance encoded in the DLT-protocol and executed via smart contracts enables decentralized management of the network. However, DLT-platforms continue to rely on centralized and informal decision-making outside the system. On-chain token distribution for incentivizing network participants in a business context is not applied yet. Instead, strategic interaction across the tokenization value chain and its participants is still built on off-chain governance mechanisms (e.g., board meetings) and bilateral business agreements.
- From a process perspective, it can be confirmed that the usage of tokens on DLT-based infrastructures offers significant benefits compared to conventional solutions. For primary markets, rights and obligations between issuer and token holder can be codified and linked via smart contracts to be enforced immediately by digital signatures of the involved parties. After issuance, the investor can access the asset token directly through a wallet. This rule-based automation reduces cost and complexity, removing preparation, negotiation, and associated manual processes (e.g., subscription orders). For secondary markets, tokens can be transferred more easily and quickly between buyers and sellers. The contractual conditions (cf. DVP) to exchange a tokenized asset for a tokenized currency are embedded into the distributed logic and instantly triggered (cf. atomic settlement). The DLT enables a trustless process without counterparty risk, reduces settlements times, and harmonizes IT in post-trade. Related activities such as corporate actions (e.g., dividend payouts) are currently investigated to be further automated via smart contracts in the future.
- Although it is widely assumed that a trustless DLT-based platform will replace custodian banks or clearinghouses (cf. CCP, Section 2.3.2), the experts see infrastructure providers in an excellent position to maintain their role based on a new function. For example, they can become regulated and trusted intermediaries between the digital- and physical (cf. physical

validator) or provide new custody services by enforcing ownership through cryptographic keys on behalf of the token holder.

- Services should follow a digital asset strategy based on fully regulated offerings for specific customer segments. Here, it can be stated that the demand for cryptocurrencies is increasing. Besides integration into existing banking services, it is appreciated to focus on new business opportunities through tokenization (cf. opening of illiquid assets). In addition, new participants can complement and contribute to the network, offering value-added services for corporate clients (e.g., KYC, AML checks). Also, the introduction of digital identities will be a critical enabler to increase the accessibility of services operating on a DLT.
- Seamless integration of DLT-based platforms into existing core banking systems and application landscapes is essential to facilitate industry adoption. Standardized APIs are needed to ensure interoperability between systems and increase the scalability of infrastructures. Especially for the tokenization process, specific token standards (e.g., ERC-20) have to be recognized as a proven industry norm within the financial services sector. Moreover, CBDCs and other decentralized payment solutions are highly appreciated to take full advantage of smart contract functionality. In addition, inter-ledger communication between DLTs enables further scalability of the platform.
- In addition to common terminology, trust-building elements must be established between all market participants. These include legal principles for interaction, data integrity, legally binding information, and transactions to increase security and acceptance for both industry and consumers.

4.6 Evaluation

After demonstrating the applicability of the conceptual model in two participatory case studies, evaluation is considered an essential step in the

DSR process (Hevner et al., 2004). Accordingly, this chapter presents the final evaluation of the artifact and introduces a qualitative approach for data collection and analysis in the first section. Finally, the second section provides the results by applying content-driven and quality-driven evaluation criteria based on the initial design requirements.

4.6.1 Process and Overview

Evaluation enables the collection of valuable feedback to improve the quality and design of an artifact (Hevner et al., 2004). The researcher needs to understand to which extent the artifact solves the organizational problem and quantify its usefulness in a given context. Therefore, the objectives of the proposed solution and the results of the artifact demonstration have to be compared (Peppers et al., 2007). Then, the artifact is either redesigned to improve its utility or finalized, providing a significant contribution to the subsequent communication. Hevner et al. (2004, p. 86) point out the importance of evaluation methods to be *“matched appropriately with the designed artifact and the selected evaluation metrics.”* Especially complex phenomena that arise from the interaction of people, organizations, and technology usually require qualitative methods for assessment (Hevner et al., 2004, p. 77).

Following the evaluation of the second artifact of this dissertation, two evaluation cycles have been conducted to ensure rigor and relevance throughout the process. Based on feature comparison, the initial design requirements in Section 4.3.1 serve as a suitable basis for a set of criteria to assess whether the initial objectives were met. (Siau & Rossi, 2011). During the two cycles, empirical data was gathered using interviews, questionnaires, and observations to be subsequently analyzed. The approaches are described below:

- Insights were drawn from two participatory case studies to evaluate conformity with the content-driven design requirements through qualitative analysis. The model demonstration followed a structured approach, where the discussion between the practitioners and the researcher was recorded and complemented

with additional notes to summarize and derive findings regarding substance and context. As a result, the instantiation from the two company perspectives provided valuable feedback to sufficiently validate the elements' applicability and the artifact's usefulness.

- The artifact was also evaluated to ensure conformity with modeling guidelines during the six multiple case studies. These rigor design requirements are met through the DSR evaluation criteria by Sonnenberg & Vom Brocke (2012) and were optionally extended by selected reference modeling guidelines (Vom Brocke, 2007). For the semi-structured interviews, each criterion was assessed using a 5-point Likert scale of 1 (fully disagree) to 5 (strongly agree). Twelve responses were collected, as qualitative comments were documented and additionally considered. The rigor of the artifact was met once the practitioners partially agreed (4<) to the first five DSR criteria by Sonnenberg & Vom Brocke (2012) (Table 4-28: DR8-D12).

4.6.2 Requirements Fulfilment

The initial design requirements in Section 4.3.1 serve as a basis for the subsequent evaluation. Regarding the first cycle, the focus lies on the content-driven criteria to determine whether predefined objectives for practice were achieved. After data collection and analysis, qualitative findings were derived and summarized in Table 4-27. As a result, it can be stated that the practical requirements were largely met.

No.	Content-driven requirements	Assessment	Degree of full.
DR1	Comprehensive blueprint	The conceptual model covers the elements and inter-relationships needed to design a holistic value architecture for asset tokenization, making it a blueprint for companies to establish innovative business models and align strategic objectives with tactical activities beyond cases in the financial services sector.	●

DR2	Strategic guidance	The network and process layer provides practitioners with a reference frame for strategic decision-making that involves the necessary elements (e.g., roles, interactions, value chain). However, there is currently limited empirical data to determine the strategic positioning of companies in this highly dynamic area.	●
DR3	Functional knowledge	The conceptual model provides a functional overview of asset tokenization and defines its elements as part of a system that includes and combines various stages (e.g., inter-organizational, process, services, technology) of value creation and delivery.	●
DR4	Technical advice	The technology layer represents a high-level architecture and addresses pivotal design decisions for describing and evaluating novel IT artifacts based on a common vocabulary. The elements do not claim to be exhaustive or be complete to enable a practical development of solutions. However, more formalized reference architectures are needed to provide also template solutions for software design or engineering.	●
DR5	Integrated approach	The artifact is built on existing approaches from the enterprise architecture domain and covers the three layers, strategy, processes, IS, and illustrates their interrelationships. It may serve as an entry point for strategy design and execution, representing a bridge between business and operating models.	●
DR6	Multi-dimensional	The model includes different overviews, building blocks, definitions, and architectural considerations from different perspectives (e.g., inter-organizational, processual). It further covers not only different levels of abstraction but also allows each layer to be separately considered or applied as a whole.	●
DR7	Consistent terminology	The artifact represents a valuable instrument that establishes a consistent and common language of asset tokenization and its surrounding phenomenon between different departments and stakeholders in business and IT.	●
Degree of fulfillment: ● Full ● High ● Medium ● Low ○ No			

Table 4-27: Qualitative evaluation of content-driven criteria

For ensuring rigor in the second cycle, the artifact was also evaluated against quality-driven criteria using a semi-quantitative approach based on a 5-point Likert scale. Based on twelve expert interviews, the final

evaluation is shown in Table 4-28. Finally, the evaluation of the conceptual model provides satisfactory results to justify its usefulness and practical relevance for subsequent communication and publication.

No.	Quality-driven requirements	Assessment	Final eval.
DR8	Completeness	The practitioners regard the conceptual model with its elements, overviews, building blocks, definitions, and architectural considerations as complete but state that it may require extension or adjustments in the future (e.g., process integration).	4.08
DR9	Real-world fidelity	The model serves as an abstract foundation and ensures real-world fidelity according to its purpose and a predefined scope. Initially derived from literature, more real-world cases for validation are needed.	4.04
DR10	Internal consistency	The artifact is internally consistent and logically stringent among all elements. The practitioners appreciate the systematic structure and highlight the common language and terminology.	4.17
DR11	Level of detail	A proper level of detail and granularity among all elements has been discussed and confirmed. In addition, the model provides a sound basis, as the aspects can be further specified (e.g., systems integration).	4.00
DR12	Robustness	The model is considered highly applicable in practice, where it provides generalizability for several use cases in the financial services domain. Its robustness for cross-industry use cases and decentralized finance applications should be further validated.	4.33
DR13	Reference character (optional)	The conceptual model partially fulfills the requirements for reference modeling, where it allows configurations of different tokenization scenarios against the backdrop of a given business context. However, the artifact does not fully claim practical reusability for company-specific information systems.	3.79
DR14	Level of innovation	The practitioners confirmed the high degree of innovation, referring to the novelty of tokenization and DLT. To the best of the authors' knowledge, a scientific sound artifact for the conceptualization of asset tokenization has not been developed before.	4.58
Likert scale of 1: fully disagree to 5: strongly agree based on n=12			

Table 4-28: Semi-quantitative evaluation of quality-driven criteria

4.7 Chapter Summary

The previous chapter investigated the elements of asset tokenization in the financial services sector to develop a conceptual model for designing a holistic value architecture for innovative token-based business models. As a result, an artifact was presented that addresses the dissertation's second research question and introduces building blocks, overviews, definitions, and architectural considerations to ensure a consistent understanding of this application area.

At first, foundational modeling approaches such as *business model frameworks*, *business engineering*, and *architectural models* with their elements, layers, and principles were discussed to establish an initial foundation for artifact development. A review of frameworks and architectures within the broader BC and DLT domains was additionally included to complement the framing. Next, six case studies were introduced (i.e., Amazing Blocks, StokenX, BEKB & daura, NYALA, SIX Group, and Bank Frick), which served as the basis for the primary data collection, exploring how fintechs and innovative financial service providers establish businesses around asset tokenization.

Following the DSR guidelines by Peffers et al. (2007, p. 11), the conceptual model was then developed in seven iterative design cycles with more than 120 changes and adjustments. The final artifact builds on a modular and multi-layered approach to support a comprehensive conceptualization of asset tokenization and practical instantiation of specific solutions. It consists of five generic layers, *network*, *processes*, *services*, *technology*, and *environment*, where each layer is addressed explicitly through separate overviews with more detailed building blocks, definitions, and architectural considerations.

After the conceptual model demonstrated its applicability in two additional case studies with practitioners, additional insights into implications and the transformative potentials for existing financial market infrastructures were gained. Finally, the artifact evaluation was conducted, where the empirical findings provided satisfactory results to justify the model's usefulness for both practice and academia.

5 Organizational Principles for Implementation

Digital products and services are transforming the everyday lives of individuals, society, and businesses, with changes affecting all company areas (Fridgen et al., 2019, p. 92). Especially for asset tokenization and its underlying DLT, various competencies across business functions are required to overcome technical and organizational challenges (Mending et al., 2018). While practitioners have to keep pace with these developments, it is essential to know what organizational changes exist and what internal factors might become subject to transformation. By addressing the third research question of this thesis, this chapter provides an overview of critical aspects of internal structures and presents organizational principles to successfully implement and operate decentralized services in the financial services sector.

This chapter builds upon the preliminary results of the author (Heines, Kannengießer, et al., 2021) and extends the contribution by providing actionable guidelines. The first section discusses related work on the organizational impact of decentralization. The second section lays out the research approach before the third part presents the mapping between identified challenges and the services of the BIAN service landscape (BIAN, 2019). Finally, the chapter closes with the definition of organizational principles in terms of eight actionable guidelines. As an enabler of tokenization, it is assumed that DLT will significantly impact the individual organization. Accordingly, DLT serves in this study as the primary subject of investigation.

5.1 Impact of Decentralization on the Organization

Today's value creation often relies on a vast network of organizations with increasingly intertwined business processes supported by centralized IS (Alt & Legner, 2008; Eurostat, 2020). While these centralized systems are typically run and operated by one party (e.g., company, cloud provider), they allow for a high degree of control, flexibility, and

cost-efficiency (Schuff & St. Louis, 2001). However, in inter-organizational settings, centralized IS also creates challenges such as non-transparent business processes and information asymmetries due to limited processing capabilities across value chains (Röck et al., 2020). With the emergence of new technologies such as DLT, organizations call for improved information flows to support inter-firm collaboration by decentralizing their IS (Heines, Kannengießer, et al., 2021).

The degree of decentralization in these systems is not only a result of the technology used but rather depends on the socio-technical aspects represented, for example, by the interaction between human agents and the DLT protocol itself (Kannengießer, Lins, Dehling, et al., 2020, p. 28). Accordingly, the decentralization of IS has to be addressed from a technical and political perspective (Rossi et al., 2019; Sunyaev et al., 2021). From a technical perspective, a decentralized IS represents a distributed system comprising multiple computing devices (i.e., nodes) that operate as one (Tanenbaum & Steen, 2007). It splits tasks specified in a shared protocol among the nodes to broadcast or propose new data stored in a distributed database. Following Sunyaev et al. (2021, p. 459), the degree of technical decentralization refers to “[...] *the number of distributed, interconnected nodes that operate independently without a central authority.*” Analogous to distributed systems, business networks (cf., business ecosystem) are represented by multiple agents (e.g., individuals, organizations) also interacting with each other. Accordingly, the degree of political decentralization depends on “[...] *equal distribution of permissions and responsibilities across all agents that independently act according to their individual incentives and work jointly on a common goal*” (Sunyaev et al., 2021, p. 460).

The implementation of DLT as an instantiation of decentralized IS involves, for that reason, multiple organizational challenges that emerge both from technical and political decentralization (Beck et al., 2018; Sunyaev et al., 2021). As a result, companies must transform existing or build new capabilities to meet these challenges and successfully benefit from a mutual usage of DLT (Wessel et al., 2021). The way business capabilities are provided is specified in one or more business

functions. They include the involved business services, people with their corresponding roles, activities with subordinate processes, and technologies (Dietz, 2006). These dependencies indicate an organizational change to provide the required capabilities successfully, not to mention that the transformation of business services and business functions can even lead to a reorganization of the entire organizational structure (e.g., flat or hierarchical organization) (Morton & Thurow, 1990; Sauer et al., 1997). Hence, companies need to understand the multiple organizational challenges of decentralized IS and its impact on the organization to anticipate implications. However, it is yet unknown which business services and related business functions may be subject to change and how to manage this transformation.

Research Stream	Collaboration and Cooperation	Governance	Integration of DLT
Exemplary RQ	<i>Does blockchain lead to the removal of intermediaries?</i>	<i>Who is involved in blockchain governance?</i>	<i>Can blockchain improve the cross-organizational workflow?</i>
Selected References	Riasanow et al. (2018); Ross et al. (2019) Sternberg et al. (2021); Tönnissen et al. (2020); Zavolokina et al. (2020)	Beck et al. (2018); Labazova (2019); Liu et al. (2021); Perscheid et al. (2020); Zachariadis et al. (2019)	Cen et al. (2017); Kannengießer, Lins, & Sunyaev (2020); Knauer & Mann (2020); Mendling et al. (2018); Fridgen et al. (2018)

Table 5-1: Extant research streams on the impact of DLT on organizations

Regarding the broad domain that investigates the impact of DLT and BC, the current state of research on the implications for organizations is further separated into three major research streams (Table 5-1): (1) *collaboration and cooperation*, (2) *governance*, and (3) *integration of DLT*. The first stream on *collaboration and cooperation* focuses on the implications of DLT on value creation across a network of organizations. This work highlights, for example, the potential for increased supply chain transparency (Sternberg et al., 2021) or reduced settlement times (Ross et al., 2019) and discusses the impact on existing inter-firm structures such as disintermediation (Tönnissen & Teuteberg, 2020) and consortia building (Zavolokina et al., 2020). Following the political

perspective on decentralization, *governance* emerged as a second key topic to discuss implications for inter-organizational coordination (Beck et al., 2018; Liu et al., 2021; Zachariadis et al., 2019) and develop mechanisms for the joint operation of DLT (Labazova, 2019; Perscheid et al., 2020). The third research stream on the *integration of DLT* discusses the impact on the individual organization and investigates the role of internal factors in the successful usage of DLT. Previous contributions focus, for instance, on the identification of adoption drivers (Kannengießer, Lins, & Sunyaev, 2020; Knauer & Mann, 2020) and the integration into the business processes of the organization (Cen et al., 2017; Fridgen et al., 2018; Mendling et al., 2018).

While the first two research streams focus on an inter-organizational perspective, it can be stated that research on intra-organizational implications has to be extended beyond operational challenges in business process management. Pan et al. (2020) highlight dependencies between enterprise capabilities and the successful use of DLT for effective leadership and efficient knowledge sharing. Since DLT is considered highly transformative, the reverse effects on the individual firm to anticipate organizational changes remain unclear.

5.2 Identification of Challenges and Solutions

For the definition of organizational principles, a three-step research approach is applied. At first, a systematic literature review is conducted to generate knowledge about the impact of DLT on the individual organization. The findings indicate a need for organizational change and provide a conceptual reference for an initial set of DLT-related challenges that may affect internal business functions. In a second step, 13 semi-structured interviews with experts from the financial services sector and associated areas are conducted to complement the results from the literature review and identify corresponding solutions. In a third step, a mapping between identified challenges and the business services is carried out. Accordingly, organizational change and corresponding solutions are defined. Finally, eight applicable principles as actionable guidelines for the financial services sector are concluded.

5.2.1 Literature Review

At first, a literature review was conducted to investigate the potential implications of DLT on business functions and generate knowledge about associated organizational changes, challenges, and solutions. The search process followed the recommendations of literature reviews by Vom Brocke et al. (2009), where known scientific databases in the business information systems domain were selected (i.e., EBSCOhost, IEEE Xplore, AIS eLibrary, Science Direct, ProQuest, and ACM Digital Library). For complementing existing knowledge from prior work on the organizational impact of decentralization, a title and abstract search was carried out in March 2021 with the following search string ("*blockchain**" OR "*distributed ledger**") AND (...)
*implication**
*challenge**
*business process**
*corporate culture**

Search string: (" <i>blockchain*</i> " OR " <i>distributed ledger*</i> ") AND (...)	Search field	EBSCO-host	IEEE Xplore	AIS eLibrary	Science Direct	Pro Quest	ACM
<i>implication*</i>	Title & abstract	386 (284)	463 (264)	31 (26)	102 (92)	92 (88)	21 (17)
<i>challenge*</i>	Title & abstract	110 (87)	585 (180)	70 (55)	421 (397)	42 (32)	228 (172)
<i>business process*</i>	Title & abstract	398 (269)	469 (245)	16 (15)	28 (28)	176 (154)	32 (21)
<i>corporate culture*</i>	Title & abstract	15 (14)	323 (173)	30 (28)	587 (544)	81 (80)	59 (45)
Sum (After non-English removed)		909 (654)	1840 (862)	147 (124)	1138 (1061)	391 (354)	340 (255)
Import into citation manager							3310
Sum (After title & abstract screening)							284
Sum (After full-text screening)							42

Table 5-2: Results of the literature search process

After removing non-English articles, 3310 results were imported into a citation manager to identify their relevance according to the research objectives. By analyzing the title and abstract, 284 remaining sources were selected that set the basis for the subsequent full-text screening. As shown in Table 5-2, the search process resulted in 42 publications.

As already indicated in the research agenda (Section 2.6.6), the existing knowledge that addresses organizational changes associated with DLT remains scarce. However, several challenges have been identified that indicate a transformational need for the individual organization. For example, research on business processes integration of DLT (Cen et al., 2017; Mendling et al., 2018) and BC consortia projects (Labazova, 2019; Lacity, 2018; Zavolokina et al., 2020) show the importance of enhancing the organization's capabilities for successful implementation. Building upon this related work, the publications allowed the conceptualization of an initial set of challenges and provided a valuable foundation to frame associated organizational principles for practice.

5.2.2 Expert Interviews

For the second step, 13 semi-structured expert interviews with 14 participants were carried out to complement the findings from the literature review with insights from practice (Ayres, 2008; Gorden, 1975). The interviewees were involved in ongoing research projects of the CC Ecosystems or were contacted based on their expertise on LinkedIn. As shown in Table 5-3, they were mainly situated in the financial services sector (e.g., financial services, IT providers, and professional services) and had comprehensive DLT project experience of 4.9 years on average. By applying a semi-structured interview guide (Appendix F.1), the experts should address the benefits and challenges of their DLT projects and reflect associated implications on the internal business functions of their respective firms. The interviews lasted about 47 minutes on average, where additional notes were taken. Each session was recorded, anonymized, and transcribed. While no new insights were found in three consecutive interview rounds, a sufficient theoretical saturation was achieved to proceed with the subsequent analysis.

The interviews were analyzed using thematic analysis (Braun & Clarke, 2012) based on six phases (i.e., familiarize yourself with the data, generate initial codes, search for themes, review themes, define and name themes, and produce the report). At first, the transcripts were read carefully to identify associated organizational changes, challenges, and

solutions using an initial coding scheme. This scheme was gradually refined by discussing the relevance of related sections and assigning them to preliminary codes. For example, the differently labeled but overlapping codes *partner management* and *collaboration* were merged into the code *stakeholder coordination* to achieve an appropriate degree of abstraction. Next, the codes were further grouped into overarching themes (e.g., governance, IT system engineering), where, for instance, the code *understanding* was assigned to the theme of *leadership and organizational culture*. After reviewing the results among three DLT experts (i.e., two researchers and one project manager), minor inconsistencies were found that led to a refinement of the code descriptions.

Use Case Domain	Company Type	Job Position	DLT Exp.
Decentralized Finance	3 banks, 3 IT-provider, 2 consulting firms, 2 IT consultancies, 1 service provider	2 product managers, 2 managing consultant, 2 IT-consulting managers, 1 sales manager, 1 founder, 1 innovation manager, 1 business developer, 1 enterprise architect	5 years
Cryptocurrency Mining	1 IT service provider	1 business developer	4 years
Legal Document Exchange	1 law firm	1 chief executive officer	8 years
Product Lifecycle Management	1 management consulting firm	1 managing consultant	5 years

Table 5-3: Overview of interviews (Heines, Kannengießner, et al., 2021, p. 3)

Subsequently, the themes were structured according to the TOE framework (Tornatzky & Fleischer, 1990), which served as framing to distinguish three sources of challenges: *technology*, *organization*, and *environment*. Finally, the results were elaborated to specify each theme and describe the codes more precisely. As a result, six groups with 20 challenges were defined with an overview in Appendix F.2.

5.2.3 Impact Mapping

The business service classification of the BIAN Service Landscape (BIAN, 2019) was applied in a third step to illustrate the organizational changes based on an impact mapping between challenges and affected

business functions. The BIAN classification consists of *business domains* and respective *business services* (Appendix F.3). A business domain is a set of responsibilities and tasks that consists of several business services. From a functional perspective, business services execute parts or complete business functions necessary to enable a business capability. The business service to perform a business function and provide a business capability defines the resources that are directly affected by the identified challenges (i.e., applied technologies, people in their corresponding roles, activities with their processes).

Based on the primary data set from the interviews, each challenge was first mapped to the BIAN Service Landscape. In particular, a service was assigned when a respondent explicitly mentioned the BIAN business service or its underlying resource affected. In additional refinements rounds, minor inconsistencies were further removed. Finally, after mapping all challenges to internal business functions, the organizational changes in the financial services industry could be revealed.

A set of organizational principles was also developed in combination with appropriate solutions derived from the primary and secondary data. Both impact mapping and principles were subsequently presented in a virtual focus group meeting with practitioners (cf. CC9 WS2) to validate the propositions and discuss further transformative mechanisms for the identified challenges. In addition to a structured discussion guide, a website with an online questionnaire was also set up (Appendix F.4). After reviewing and prioritizing distinct activities, the steps towards transformation were defined. As a result, the knowledge was accumulated to generate eight principles in terms of actionable guidelines for the financial services sector.

5.3 Challenges and Affected Business Services

This section highlights the organizational changes by mapping the various challenges of DLT implementation to the organization's internal business functions. For every dimension of the TOE framework, the relevant themes and challenges are presented to illustrate their impact

and refer to the corresponding BIAN business services affected. If applicable, potential solutions to overcome these challenges are also introduced. As a result, 36 business services within 13 overarching business domains are impacted and the subject of organizational change.

5.3.1 Impact of Technology on the Organization

The technological context considers all factors of DLT that emerge from technical constraints and potential functionalities when DLT is introduced in an organization (e.g., technological characteristics; Tornatzky & Fleischer, 1990). As shown in Figure 5-1, three themes with nine challenges were identified in this dimension: *administration and coordination*, *IT system engineering*, and *user-centered application design*.

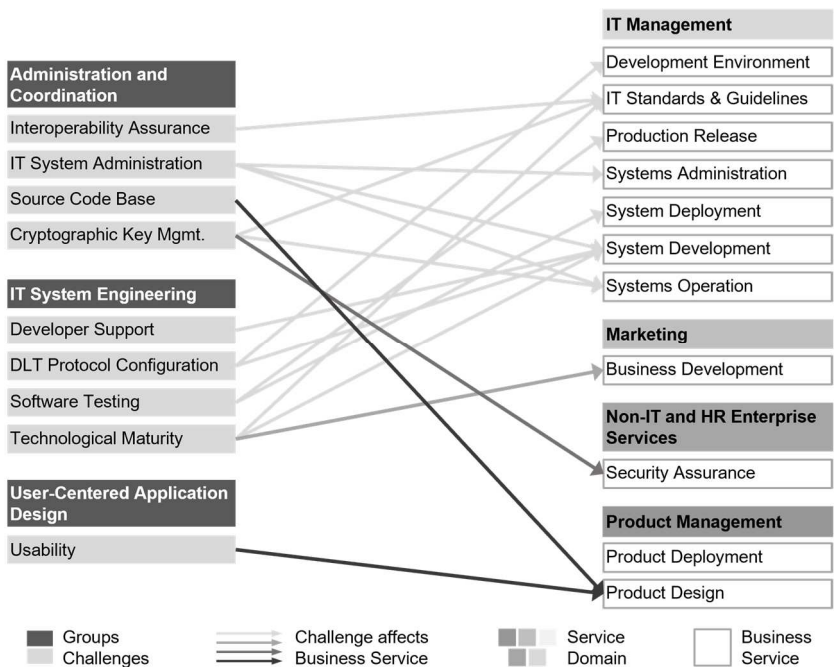


Figure 5-1: Impact of technology on the organization

5.3.1.1 Administration and Coordination

The theme, *administration and coordination*, refers to various challenges associated with tasks and responsibilities of managing software systems, source code maintenance, and system administration.

Interoperability assurance describes the increased difficulty of integrating new system components or maintaining existing ones. From an intra-organizational perspective, the business service *IT standards & guidelines* has to provide practices that ensure the system's ability to operate with non-DLT based system components (e.g., compatibility): “[...] you connect your data with the required standards [...]. Your SAP system, your warehouse management system, even your MES [...]. You have to create an interface so that development efforts can go hand in hand with that.” (Management consultant). New policies and standards are required to improve the integration of legacy systems or maintain existing IT architectures as part of a decentralized IS.

IT system administration efforts increase due to the additional work required to manage IT systems (partially) operating on DLT-based platforms and directly affecting the business functions: *systems administration, -operation, and -development*. The additional overhead prevents efficient management of IT assets across applications landscapes, including scheduled operations, usage status, and backup procedures: “[...] So you have hundreds of applications that you either run on your own or get through interfaces. But at the end of the day, you have a stack and different modules there. And that would be an additional point.” (Management consultant). Knowledge of integrated IT structures, patch management, relocation, or systems maintenance is needed to improve associated activities. Also, expertise in DLT components (e.g., DLT programming languages) must be established to understand software behavior and anticipate security breaches.

Source code base poses challenges related to the uncertain extent to which a decentralized IT system depends on one or more third-party vendors (e.g., cryptocurrency wallets, cloud providers) to function as

intended. It is associated with the business service *product deployment* and exacerbates planning and administration, adding complexity to deployment activities: “[...] *you have other applications, off-chain applications, that allow access to the on-chain elements, for example, a wallet. With the wallet code, the error is non-public and often very complex. Only insiders can understand that.*” (IT-consulting manager). Best practices and appropriate tools for source code management have to be in place. Also, close collaboration with product teams early in the process ensures transparency and prevents higher development costs.

Cryptographic key management refers to the difficulties associated with creating, storing, and using cryptographic keys for interaction with the underlying DLT (e.g., signing of transactions). Compared to centralized public key infrastructures (PKIs), DLT enables an independent creation of cryptographic keys (e.g., wallet keys). The key owner is responsible for safekeeping (i.e., non-custodial), and the keys cannot be recovered if lost. This additional overhead affects the three business services *IT standards & guidelines*, *systems operation*, and *security assurance*. The responsibilities associated with cryptographic key management require security countermeasures and assurance checks to increase protection against different threats and scenarios: “[...] *someone in the organization must have the keys, or there must be a procedure, a two-person rule, to ensure that the right transactions are executed or not. Keys may be passed or recovered. That is not quite simple.*” (Product manager). As stated by an innovation manager, the “[...] *custody is currently outsourced.*” Organizations that directly interact with the DLT must implement new processes from scratch to manage the keys on behalf of their employees or customers. Accordingly, many companies follow outsourcing practices and transfer responsibilities toward external providers.

5.3.1.2 IT System Engineering

The theme *IT system engineering* describes challenges related to the design, implementation, and operation of decentralized IT systems.

Developer support describes the difficulties in developing applications based on DLT. For example, existing development kits and tools for implementing smart contracts rarely support the local execution of developed applications in a runtime environment under realistic conditions. Compared to established software, the low degree of developer friendliness further exacerbates the effective solution design of DLT-based applications and significantly affects the business service system development: “[...] *there are still two main problems: Usability, which many people, including us, are working on and the way blockchain transactions were implemented in the past, respectively smart contracts. Of course, that will not work anymore.*” (IT-consulting manager). New development capabilities for writing and maintaining source code are required to improve developer friendliness and increase flexibility.

DLT protocol configuration refers to multiple dependencies and tradeoffs between different DLTs and their technical characteristics, making the selection of an appropriate protocol for a specific use case often complex. Compared to conventional solutions, the wide range of DLT protocols and possibilities for different configurations might also lead to unexpected systems behavior. As a prerequisite for an effective software development process with DLT, additional investments in several tools, alternative infrastructures, and environments are usually necessary. These considerations can affect the business services *development environment* and *systems development*. As a result, decision-making tools and industry standards must be further developed and established to reduce complexity and associated costs.

Software testing relates to challenges for achieving full software test coverage caused by the architectural characteristics of a DLT system (e.g., connected off-ledger software and lack of software testing tools). In many cases, existing functional or non-functional test evaluation criteria and established test routines cannot be applied. Both *production release* and *system deployment* represent affected business services. According to the experts, known practices have to be adapted: “[...] *We have to figure out how the end-to-end testing is done. That is not so easy. Looking at banks, they are still thinking in the past.*” (IT consulting

manager). Improving associated activities requires organizations to setup up secure and functional infrastructures. In particular, companies must invest in DLT testing expertise and resources to identify the right testing tools. Moreover, a systematic testing strategy is needed to be aligned with the selected DLT type.

Technological maturity refers to insufficient theoretical and practical knowledge about reasonably designing and using DLT. This immaturity leads to a lack of know-how in developing, maintaining, and enforcing IT architectures according to appropriate policies and standards. Affected business services are *system development*, *IT standards and guidelines*, where missing expertise also influences decision making within *business development* and activities around new market segment entry, product specification, and product coverage: “[...] *You cannot predict the transaction volumes, how much capacity you need. In this particular early phase, it is difficult for IT departments [...] to estimate what resources and requirements they would have.*” (*Management consultant*). A deep understanding of metrics based on DLT industry experience is required to improve related activities. Especially data provisioning as a combination of people, processes, and technology is crucial to enable responsible and efficient decision-making.

5.3.1.3 User-centered Application Design

The theme *user-centered application design* encompasses the challenges associated with application design for the end-user of DLT-based systems that prevent them from efficiently achieving their goal.

Usability describes difficulties that pose a usability challenge for end-users applying unhandy cryptographic keys and digital signatures in DLT-based applications (e.g., DApps). While centralized applications usually require a username and password for authentication, DApps rely on digital signatures based on multi-digit cryptographic keys (i.e., private keys). Following these characteristics of the technology, the business service *product design* is affected that specifies how DLT-

based applications are created, designed, and maintained: “[...] you have the risk that employees are overwhelmed because I often see that DApps are horribly complicated in terms of usability or user experience. The main unique selling point has always been that it is driven by block-chain, and that is not an argument for using such a technology in a company.” (Chief executive officer). Therefore, new user-centered design principles must be addressed (e.g., signing transactions). Also, the provision of new web browser-based frontends (cf. GUI, Section 4.4.5) may facilitate the integration and user adoption (e.g., MetaMask).

5.3.2 Impact of the Organization on Itself

The organizational context is based on the current characteristics and resources of the organization (e.g., scope, size, and structure; Tornatzky & Fleischer, 1990), which determine the ability to respond to external or internal changes in the use of DLT and corresponding innovations. As Figure 5-2 illustrates, two challenges are presented in this dimension: *understanding* and *acceptance*.

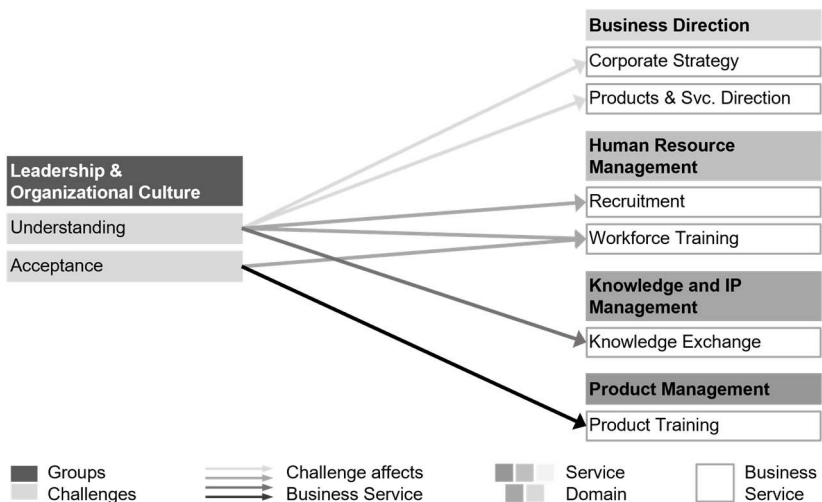


Figure 5-2: Impact of the organization on itself

Leadership and organizational culture

The theme *leadership and organizational culture* cover all challenges associated with cultural change related to employees' norms, attitudes, and behaviors to support DLT adoption.

Understanding describes the required knowledge of employees about the decentralization of IS using DLT. An insufficient understanding leads to mismanagement and ineffective communication. It affects several areas, starting with strategic management associated with the business service *corporate strategy* to formulate and implement long-term goals: “[...] I see the management level as an enabler that must initiate a culture change. They must propagate and clarify the vision that we will have to operate more and more across industries in the future. If they have envisioned it, then it should work.” (Product manager). New capabilities are also needed in the two business services, *knowledge exchange* and *product & services*, to provide structured access to know-how: “[...] It is the buildup of competencies about blockchain. [...] That's almost focused on one person in our company right now. If he drops out, we have a problem. [...] Who creates a wallet for the customer and so on? It is no longer the project manager; it must be transferred to operations somewhere. And who does that in operations? If the person has no know-how and is not familiar with the terms, it is extremely difficult. That brings us back full circle to knowledge transfer.” (Innovation manager). Following the expertise and skills, it can be stated that both business services, *recruitment* and *workforce training*, play an essential role in organizational change. One of the most critical factors is human capital: “[...] That is the thing about human resources. That is the hiring process, recruiting as well as training. Whether they are internal to the company or not.” (Business developer).

Acceptance covers the difficulties in overcoming internal resistance to DLT adoption. This condition is often caused by a lack of employee willingness to react and adapt to changes promptly and appropriately (e.g., a new business process). It leads to increased efforts to encourage employees to reevaluate daily job routines and arrive at entirely new

solutions in the context of innovation. From an intra-organizational perspective, it affects the business services *product training* and *workforce training*: “[...] I'll give you an example in commodity trading. They do not want to do it differently. There are maybe one or two people who are passionate about it. The majority will not want to do it. It's as simple as that; you need an incentive.” (Innovation manager). Creating tangible commitment (e.g., employee participation) and providing training tailored to a specific group of employees helps overcome internal resistance. Also, increased transparency in decision-making processes may convince the organization of necessary changes.

5.3.3 Impact of the Environment on the Organization

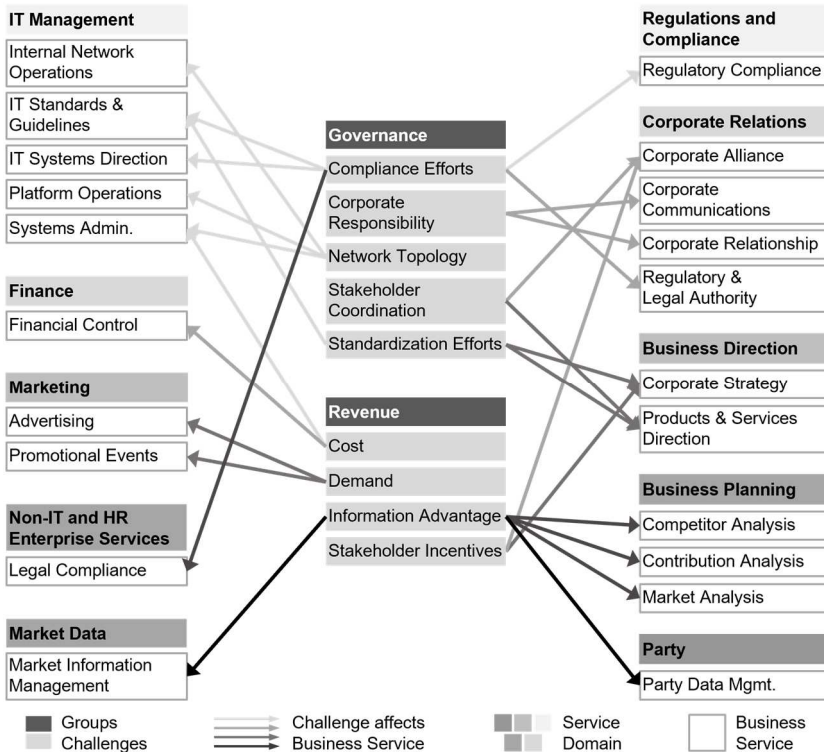


Figure 5-3: Impact of the environment on the organization

The environmental context refers to external factors for DLT implementation. It describes all uncertainties related to market demand, industry specificities, regulatory requirements, legal issues, cooperation, and competition for the organization and its surrounding environment (Tornatzky & Fleischer 1990; Section 4.4.6). As shown in Figure 5-3, nine challenges and two groups were identified: *governance* and *revenue*.

5.3.3.1 Governance

The theme *governance* describes a set of challenges associated with the mechanisms, rules, and processes that ensure accountability, decision-making, participation, and interaction for designing, implementing, and operating the value network based on DLT (Section 4.4.2.2).

Compliance efforts represent difficulties in meeting regulatory obligations and legal requirements when using DLT. For example, an implementation is typically associated with uncertainties caused by missing frameworks, complex dependencies, and limited legal advice. In addition, new relations and knowledge with regulators and government agencies have to be established. In this case, *regulatory compliance*, *IT systems direction*, *legal Compliance*, *regulatory & legal authority*, *IT standards & guidelines* represent the five affected business services. “[...] certain countries dictate that you are not allowed to hold customer data in another country. [...] From a legal perspective, you have to say where the data is located and where it can be accessed.” (*Management consultant*). It is suggested to acquire the necessary expertise early in the product design process to follow new developments in this area and anticipate changes for complying with existing laws. Especially in highly regulated environments, companies should closely involve specialized lawyers and proactively approach regulators and policymakers.

Corporate responsibility refers to the difficulties in strategic decision-making and the increased efforts to assess the impact of DLT-based innovations on society, employees, and the environment. The benefits of DLT as emerging technology are relatively difficult to understand for

less tech-savvy people. As a result, unclear objectives prevent effective communication and add complexity to managing corporate relationships with key partners and stakeholders. (e.g., clients, political and industry groups, user associations): “[...] *at the end of the day, once the process is automated, they have fewer jobs, for example. Then you have got real efficiency gains. Who wants that? You would have to lay off half of all savings bank employees; what do they actually do all day? So if we digitize, we will not need them all anymore. What is going on then? And blockchain is just a natural extension of this digitization theme.*” (Founder). Investments in corporate communication improve information dissemination and internal organizational communication with key stakeholders (e.g., C-suite, investors). Companies are further advised to differentiate between their target groups.

Network topology relates to non-trivial decisions and their resulting responsibilities on DLT node operation that may lead to ambiguity for the participating entities within the network (e.g., individuals, organizations). While the outcomes of these decisions are often not fully known in advance, the decision-making process is affected by insufficient information. For example, metrics are currently missing to accurately assess how the infrastructure should be operated in a particular configuration (e.g., administration of access rights). Moreover, the challenges make it difficult to monitor DLT transactions. As a result, the business services *platform operations, internal network operations, and system administration* are impacted: “[...] *Yes, I think it depends on the use case. And it also depends on the extent to which the blockchain can exploit its advantages [...] not everyone has to host a node [...] I would say that 15 nodes are enough in this context [...] You can also say that it rotates. At first, 15 people have a node, then in 2 years the others have to take over.*” (Management consultant). Thus, several companies consider outsourcing a viable approach to improve associated activities: “[...] *In the bank, you have a few process adjustments. But in the end, it is outsourcing, and you don't do it yourself.*” (Product manager).

Stakeholder coordination refers to the additional efforts required to initiate and manage a DLT-based business network of organizations (cf.

business ecosystem), including business activities such as coordination, communication, and resource allocation between stakeholders (e.g., onboarding new stakeholders). External involvement adds complexity to developing appropriate product and service policies and exacerbates efficient communication towards the network's stakeholders. In this case, the two business services *product & services direction* and *corporate alliances* are affected: “[...] We are heavily distributed internally, and of course, that's only useful if you have a network somewhere where you can get everything together again, where you get business functions synergies together in such a way that you have that. But we do not have that.” (*Business development*). It is suggested to integrate a dedicated *ecosystem management function* to coordinate related activities and jointly develop capabilities for the network as a whole.

Standardization describes the additional efforts to agree on technical standards for DLT-implementation with the various stakeholders (Section 4.4.6). This additional overhead creates complexity in developing shared IT architectures and achieving inter-organizational compatibility and interoperability. Following this, *IT standards & guidelines*, *products & services direction*, and *corporate strategy* represent the primarily affected business services: “[...] I think one of the main challenges of decentralization is that you have to agree on standards that everyone will use. If you only use the software in your company, then you can, of course, adapt it very individually to your needs.” (*Management consultant*). Industry experience and collaboration with relevant actors are needed to optimize, for example, the efficiency and effectiveness of DLT-projects or software engineering. In addition, the experts suggest an engagement with existing standardization groups or collaboration with a technical-oriented DLT consortium.

5.3.3.2 Revenue

The theme *revenue* is associated with several challenges that cover strategic decisions about participation in a DLT-based business network involving the commitment of funds and shared resources.

Cost refers to the difficulties in estimating the operational costs based on external dependencies that a single organization as part of the network cannot control (e.g., smart contract transaction fees). Compared to conventional IT assets, missing estimation models may prevent an accurate evaluation of DLT projects and make it challenging to approve financial budgets. Especially for first-moving companies, new products and services lack empirical data to generate meaningful financial projections. As a result, the profitability of new market outcomes is often not predictable. In this context, the two business services, *financial control* and *systems administration*, are affected: “[...] when we look at tokenization in particular. We still have a small market. It is not possible to generate revenues there for quite some time. An outsourcing model is a way to go because you have economies of scale again and don't have to build everything yourself.” (Management consultant).

Demand refers to the risks of lacking consumer demand caused by a slow market diffusion and the small number of showcase projects building upon DLT (e.g., cryptocurrencies or supply chain tracking information). This missing or misconceived demand for both business and end-consumer directly affects the profitability of business cases and prevents the platform and business model from scaling. Therefore, to stimulate and revive demand, marketing plans have to be implemented or reconsidered to increase the visibility of the existing offerings. From an intra-organizational perspective, both *advertising* and *promotional events* are affected. In addition, full visibility of market developments is required to manage stakeholder expectations effectively.

Information advantage describes challenges in strategic decision-making associated with a potential loss of competitive advantages by the participating organization within the business network. Although various DLT-solutions might ensure data confidentiality (e.g., on-chain meta-data), the individual firm may still consider that the increased information-sharing capabilities of DLT are contrary to its interests. In highly competitive environments, the divergent interest may hinder inter-organizational knowledge exchange and limit access to a comprehensive set of reference data (e.g., customer data, product master data). As a

result, various business services are affected: *party data management*, *contribution analysis*, *competitor analysis*, *market analysis*, and *market information management*. Besides a strategic shift from competition to coopetition, feasibility studies should be conducted for use cases to support the decision-making processes.

Stakeholder incentives refer to challenges in designing decentralized business networks caused by the heterogeneous nature of the diverging, sometimes contradicting business objectives of the organizations involved. As the underlying DLT consists of multiple nodes to be operated by individuals or organizations, the benefits for each stakeholder and individual use case have to be considered to scale the platform successfully. According to this long-term focus on building relationships and incentivizing the network participants, the business services *corporate strategy* and *corporate alliance* are affected. The experts describe the benefit of establishing a DLT-based business network: “[...] *The ecosystem draws solutions out of the DApps store and after the standardization has been solved, they are automatically networked with each other. That is how the interaction is supposed to work. The operating company just provides the underlying technology, the marketplace, and the integration and compensation begin.*” (IT consulting manager). Apart from a separate management function for stakeholder coordination, it is also appreciated to allocate resources and establish ecosystem design and network management capabilities.

5.4 Principles to Guide Organizational Change

By mapping the challenges with the internal business functions, organizational changes across several service domains and respective business services were illustrated. The study has shown that not only the area of IT management is subject to change, but that non-technical functions (e.g., human resources management, marketing) must also be transformed. These changes affect the company as a whole, its people, procedures, technologies, associated resources, and address strategic and operational structures (e.g., corporate strategy, platform operations). The literature review and interviews revealed corresponding

solutions to anticipate the required internal transformation and facilitate a successful implementation of DLT. As a result, eight organizational principles were defined to complement this study and help practitioners address the identified challenges and mitigate organizational risks in DLT implementation. Finally, the insights are summarized in terms of actionable guidelines, shown in Table 5-4 and described below.

Principle	Description
Reshape Organizational Culture	Development of an open-minded, purpose-driven, and collaborative culture to enable distributed value creation and joint innovation
Enable Employees	Extension of required skillsets by sourcing key resources and building up employee knowledge with HR learning & development
Decentralize Decision Making	Setting up decentralized organizational structures that provide flexible role design, autonomy with purpose, and minimal constraints
Align Strategic Goals	Management of objectives and processes according to short- and long-term value of DTL, its platform, and infrastructure capabilities
Engage with Regulators	Proactive engagement with regulators early in the process and consistent monitoring of the legal landscape for compliant solutions
Establish a Viable Ecosystem	Creation of a minimal viable ecosystem and preparing for platform scalability based on stakeholder incentives and network effects
Implement Shared Governance	Setup of mechanisms, rules, and processes that ensure accountability, decision-making, and participation within the ecosystem
Focus on Integration and Standards	Primary focus on DLT integration based on close collaboration and industry standards to ensure interaction with existing systems

Table 5-4: Principles for organizational change in DLT implementation

Reshape Organizational Culture: The organizational culture is defined as a collective set of values and beliefs and affects almost all areas within the organization ranging from decision making, leadership, communication, and relationships to colleagues, customers, and suppliers (Rosemann & vom Brocke, 2010). For asset tokenization and DLT adoption, in particular, it can be stated that focusing on an open-minded, purpose-driven, and collaborative culture (cf., adhocracy) positively influences organizational members to achieve their goals more successfully (Mendling et al., 2018). For example, DLT *“enables companies to collaborate but still share power and thus create innovative artifacts, that serve unserved [...] needs”* (I. Bauer et al., 2019, p. 10). In combination with customer-centricity, value is created through DLT

to establish new forms of trust in customer relationships. Also, developing products and services requires a paradigm shift to a business ecosystem perspective with more cooperation and collaboration.

Enable Employees: The organization relies on employees who share the company's culture and apply their knowledge and skills in various roles. In terms of the individuals' acceptance and understanding of decentralized IS, DLT requires fundamentally new knowledge and willingness to engage in these new structures. These skills relate not only to technical (e.g., software engineering, cryptography) but also to business-oriented areas (e.g., partner management, compliance) (Guggenberger et al., 2021; Mendling et al., 2018). One option is to acquire missing key resources through new hires and outsourcing, but companies are encouraged to build up knowledge in the long term in close collaboration with human resources (HR) (e.g., education, training, workshops). Combined with an environment that unlocks the intrinsic motivation of employees, workforce agility can be further increased to react and adapt to changes caused by decentralization more quickly.

Decentralize Decision Making: Especially for technical developments, the organizational structure with its roles and responsibilities is a critical factor for the quality and time-to-market of products and services (SAFE, 2021). For DLT implementation, it can be shown that building on separate and loosely coupled business units results in fewer challenges and easier integration than in strictly hierarchically organized structures with fixed defined roles (cf. holacracy). Strategic decisions might still be made centrally, but decentralized decision-making and flexible role designs increase lead times and allow for faster iterative product design. Also, the separation between the implementation of DLT and operations of existing systems reduces transitions risks.

Align Strategic Goals: Depending on its business model, the organization must consistently align its objectives and processes to enable effective actions for improved business outcomes. On one side, asset tokenization and DLT may require a clear business case to establish management support. On the other side, R&D platforms exist that might

never reach profitability. In these cases, two distinct dimensions are introduced to resolve potential conflicts strategically using DLT. First, a differentiation between short-term and long-term goals is required (Guggenberger et al., 2021). Secondly, a difference between the platform and its underlying infrastructure must be drawn (Zavolokina et al., 2020). Shared operational efficiencies, for example, create business value in the short term but may rely on new infrastructure capabilities (e.g., custody of cryptographic keys).

Engage with Regulators: Legal and regulatory frameworks affect DLT-implementations and may not only apply to products to be provided on regulated markets (e.g., asset tokens) but also to the infrastructure itself (e.g., protection of sensitive on-chain data) (Section 4.4.6). Nearly all DLT-based initiatives can become subject to regulation, where system modifications at a later stage are often costly to eliminate legal concerns. In addition, “*some regulators are supportive [...], some are not and still others have yet to deliberate*” (Lacity, 2018, p. 217). As a result, organizations must proactively engage with regulators early on to design compliant solutions and constantly monitor changes in the legal landscape throughout implementation (Guggenberger et al., 2021). While national legislation is still in development, organizations are often encouraged to share their industry experience with legislators.

Establish a viable Ecosystem: Asset tokenization requires more collaboration between organizations as DLT follows a distributed logic among various components (e.g., computing nodes, on-chain data). After strategic alignment and positioning, organizations must establish a minimal viable ecosystem with “*reliable technical enablers, financial partners, and legal advisors who are well versed in blockchain, smart contracts, and digital tokens*” (Sazandrishvili, 2020, p. 5). Whether it is about a technology partnership or a business-oriented consortium, stakeholder incentivization plays a significant role by shifting from the production stage to the platform's scalability. A strategy to achieve a critical mass of customer and expectation management for distributed value generation of participants is needed, ranging from shared operational efficiency to distributed products (I. Bauer et al., 2019).

Implement shared Governance: For ensuring accountability, decision-making, participation, and interaction between organizations, notions of governance must be implemented. Especially for establishing a DLT-based ecosystem, a significant trade-off between centralized and decentralized control must be drawn (Section 4.4.2.2). According to this, several shared governance models with specific manifestations exist (e.g., plutocratic, democratic), which have to be defined separately from the perspective of an ecosystem, platform, and infrastructure. However, in an ecosystem with long-term goals, a leading company with a substantial upfront investment is often necessary to accelerate decision-making and platform development.

Focus on Integration and Standards: The parallel operation of existing infrastructures and the development of new solutions lead to higher costs and an increased allocation of resources. As a result, seamless integration of new system components is required to overcome transition risks and ensure interaction with the existing legacy system early in the process. Particularly for emerging technologies, such as DLT, standards are essential for enabling interoperability between systems and establishing the inter-organizational infrastructure. Where best practices are still in development, close collaboration between stakeholders, consistent observation of technological developments, and active engagement in standardization are needed.

5.5 Chapter Summary

The chapter addressed the third research question of this thesis by identifying the challenges caused by DLT and illustrating their impact on the internal business functions of firms. As a result, transformational needs were highlighted to derive organizational principles that anticipate change, mitigate risks, and facilitate successful implementation.

Related work revealed that DLT creates multiple organizational challenges that emerge both from technical and political decentralization. Following this, companies are typically required to transform existing or build new capabilities to overcome these challenges and successfully

benefit from a mutual usage of DLT. While research on intra-organizational implications remains scarce, a systematic literature review was conducted to identify an initial set of challenges and frame associated organizational changes in practice. The findings were further refined and complemented through 13 semi-structured interviews. As a result, organizational changes were identified by mapping 20 challenges to 36 internal business functions using the BIAN service landscape. It can be stated that mainly non-technical functions are subject to change (e.g., regulation and compliance, corporate relations), where employees' acceptance and understanding are seen as key enablers.

Based on an instantiation, organizational principles in terms of eight actionable guidelines were further derived, evaluated, and prioritized in focus group meetings, namely (1) *reshape organizational culture*, (2) *enable employees*, (3) *decentralize decision making*, (4) *align strategic goals*, (5) *engage with regulators*, (6) *establish a viable ecosystem*, (7) *implement shared governance*, and (8) *focus on integration and standards*. In addition to the first overview of critical aspects that imply organizational change, the principles complement the findings to overcome internal resistance and prepare practitioners for DLT-implementation and decentralized services associated with asset tokenization.

6 Discussion and Conclusion

This chapter summarizes the results of the dissertation and outlines its contributions to the existing body of knowledge. Accordingly, the first section highlights the overall findings before the implications for research and practice are presented. Finally, the work concludes with a critical reflection on limitations and an outlook on future research.

6.1 Summary of Results

This dissertation explored the concept of asset tokenization as a new way to manage asset ownership through the creation of tokens typically representing valuable objects or contractual rights. Once the reference on a DLT-based platform is established, the issuance, transfer, and storage of tokens can reduce the drawbacks of centralized platforms usually managed and operated by one party. With the ability of DLT to replace centrally authorized ledgers and mediate transactions between firms without a single central authority, it has been shown that tokenization is not only expected to transform established market infrastructures but also provides the opportunity for novel services and frictionless collaboration in the financial services sector.

Based on the emergence of these new asset tokenization business models, organizations are encouraged to dive into the applicability, design, and implementation of this phenomenon to increase value creation and gain competitive advantages. In doing so, the dissertation proposed a frame of reference that determines the business potential of tokenization, allows the design of value architectures, and highlights guiding principles for successful implementation. For addressing this holistic foundation, this work created three artifacts to support business model innovation in the financial services sector.

The first artifact represents the *assessment framework for ideation* to illustrate how companies can strategically apply tokenization to innovate their businesses. The research outcome refers to a model and answers the first RQ by providing a set of assessment criteria to

individually define the business potential of asset tokenization in a given scenario. For that reason, the perspective on token properties was extended with selected aspects of their applicability (i.e., drivers and barriers of the tokenization) to identify the role of tokenized representations as part of a broader business model. Based on a literature review, expert interviews, and focus group meetings, 12 dimensions with 44 sub-criteria were identified. The results confirmed the initial assumptions that the same tokenized object exhibits a multipurpose ability for different use cases. A tokenized watch, for example, can be utilized to improve track and trace or facilitate investment access. In addition, the artifact was applied in a morphological analysis based on 129 ventures and their token-based business models. This empirical approach indicated patterns of recurring combinations that resulted in eight asset tokenization archetypes (e.g., programmable money, crowd financing). The multifaceted approach captured the current state of the tokenization ecosystem, highlighting the vast potential of a token economy not limited to tokenized bankable assets in the financial services sector.

The second artifact provides a *conceptual model for design* and addresses the second RQ of this dissertation by presenting a blueprint for value creation in asset tokenization business models. Based on secondary and primary data, the model introduces five generic layers at its highest level (e.g., network roles, processes, services) and presents pivotal elements for each layer that further consist of building blocks, overviews, definitions, and architectural considerations. These interrelated aspects form asset tokenization networks as a whole and establish a shared understanding of this complex and dynamic system. The conceptual model was further applied in two single case studies, where its modular and multi-layered structure supported a comprehensive conceptualization of asset tokenization and instantiation of value architectures in practice. Based on these insights, the layers follow a top-down approach to be structured according to their degrees of abstraction ranging from highest (cf. network) to lowest (cf. technology). While asset tokenization might lead to disintermediation of existing financial market infrastructures, the cases have shown that shared operational efficiencies are currently a primary driver for adoption.

The third artifact describes a set of *organizational principles for implementation* and summarizes the transformational need to benefit from asset tokenization and successfully address the organizational changes caused by DLT. In particular, the research outcome represents an instantiation and answers the last RQ by defining challenges for firms in DLT implementation and their impact on internal business functions. Based on a literature review and interview study, 20 challenges were identified, impacting 36 business services within 13 overarching business domains. As these results were further refined in focus group meetings, eight actionable guidelines for the financial services sector were concluded to anticipate transformation and facilitate successful implementation. Thus, an organizational change beyond technical areas is required, where the interviewees prioritized the need to increase employees' acceptance and understanding. In addition, processual and technical standards are needed to leverage synergies effectively. However, a high degree of standardization can also lower technological entry barriers between companies and increase the risk of substitution.

Besides these primary outcomes, additional insights showed that the impact of asset tokenization and the management of asset ownership via distributed ledgers directly affect the core functions of financial intermediaries (Section 2.3.1). Without relying on mediation by trusted third parties, three main implications for financial intermediation can be derived in a simplified form. Firstly, decision making, where capital resource allocation shifts from single trusted intermediaries towards a system of equipotent users (e.g., community-governed). Secondly, record-keeping, while distributed ledgers reduce transaction costs by removing the complexity of balancing accounts of multiple centrally managed registers (e.g., international money transfer using payment token). Thirdly, risk allocation, where operations move from one single point of failure to a network of separate computing devices (e.g., validator nodes). These developments can already be observed in the unregulated space of DeFi with dedicated services in the area of decentralized lending, investing, and exchange of cryptocurrencies (e.g., DEX, DAO).

However, intermediation will still be relevant and required in the middle term (e.g., enforcement of contractual obligations between the digital and physical world). Therefore, the focus lies in integrating centralized and decentralized infrastructures to redefine traditional functions in the financial value chain rather than making existing participants obsolete.

6.2 Contributions to the State of the Art

The dissertation contributes to a new concept in the IS domain and highlights the practical relevance of developing unique business models around technological innovations. Accordingly, the frame of reference with its three artifacts serves as a first foundation to enable asset tokenization business models in the financial services sector and support their ideation, design, and implementation. While practitioners have emphasized the need for decision support on this phenomenon (Section 2.6.1), this work has addressed this problem area by providing insights about business potentials, value creation, and organizational principles to adopt asset tokenization successfully.

The overall framework also contributes to business model theory by extending its component-oriented perspective (Section 2.4.2). Following Stähler's (2002) main business model components, the first artifact addresses the value proposition of tokenization, while the second and third artifacts provide new insights on value creation and delivery. However, value capture has been neglected because various company specifics cannot be included in the general tokenization concept, which is beyond the scope of this dissertation. Moreover, the artifacts complement existing approaches by covering three business model innovation phases (i.e., ideation, design, implementation) as well as strategic, operational, and technical aspects (Section 2.4.3). As a result, the combined usage with other frameworks and methods (e.g., business model canvas, business engineering) can broaden the scope of this work and increase the usefulness of the developed artifacts. Based on the three main findings of this dissertation, the implications for theory and practice are further discussed in more detail below.

The *assessment framework* supports practitioners from innovation, (IT) strategy, and (asset) management to determine the business potential of asset tokenization in the context of predefined criteria (cf. token properties, drivers, and barriers for adoption). It serves as a decision aid tool to create, compare, and communicate viable ideas for various tokenized assets (e.g., art, gold). Moreover, it contributes to practice by introducing eight archetypes of asset tokenization. The patterns reduce complexity and illustrate differences and similarities in existing token-based solutions as a starting point for companies to innovate their businesses. The artifact differs from existing classifications by providing a scientific foundation and adding new criteria that capture the role of tokens as part of an operating or business model (e.g., increased liquidity, process optimization). For academia, this work extends the current knowledge base with novel empirical insights on archetypical use cases and fosters an understanding of new applications apart from cryptocurrencies. By bridging the gap between established business models and novel token-based use cases, the artifact combines multiple perspectives for interdisciplinary research on the opportunities of a token economy beyond mere disintermediation of existing market structures.

The *conceptual model* assists practitioners from IT, business architecture, technical consulting, and requirements engineering to design a conceptual architecture for value creation in asset tokenization business models. The artifact addresses the need for a blueprint in practice and provides a common understanding to conceptualize new business solutions based on predefined building blocks, overviews, and definitions with architectural considerations. Its set of pivotal elements helps break down this complex system into several layers to describe, analyze, and identify interdependencies. More specifically, it might serve, for example, as an entry point for a target operating model or enhance existing business architecture frameworks. This work contributes to research by providing an integrated approach that bridges the gap between a technological and business-oriented understanding of the DLT domain (Section 4.1.2). Especially the conceptualization of elements beyond the technical architecture (e.g., network roles, services) allows

for investigation of the setup of other decentralized networks from both a strategic and operational perspective.

The *organizational principles* enable practitioners from innovation, (IT) strategy, and business development to anticipate transformation and overcome internal resistance for a successful implementation of asset tokenization business models. The principles refer to eight actionable guidelines and are based on organizational changes caused by the usage of DLT. The challenges of DLT-implementation and their impact on internal business functions create an understanding to enhance organizational capabilities beyond technical factors and help decision-makers specify the required transformational needs. While the insights into internal structures span the technological, organizational, and environmental context, the principles summarize these findings to prepare companies for the identified challenges and mitigate organizational risks in DLT implementation. In addition, this work contributes to research in two ways. On the one hand, the results expand the existing scientific knowledge base by providing an intra-organizational perspective on novel implications of DLT and decentralized IS for internal business functions and structures (Section 5.1). On the other hand, the insights serve as the groundwork for identifying transformative mechanisms in other industries and more specific problem domains.

6.3 Limitations and Further Research

A critical review of the dissertation's research activities and results is appreciated, as the chosen scope, applied methods, and collected data of this study may lead to limitations. In addition, a closer look at further research is taken. Especially for the IS domain and other application areas, there are several opportunities to utilize and further develop the frame of reference with its three artifacts.

Several limitations refer to the collection of secondary data. In this context, the artifacts rely on a comprehensive literature review, where the search process might not cover all existing scientific literature and academic sources. Due to the novelty of the tokenization concept in

research, the presented findings are additionally based on grey literature and non-scientific references to enhance data collection. For the assessment framework, it cannot be claimed that the proposed criteria are complete or stop the need for further research at this intersection. Therefore, exhaustive and mutually exclusive principles, known from taxonomy building, have been neglected in the development process. Also, the conceptual model and the identified challenges of the third artifact build upon an initial set of elements derived from secondary data. Accordingly, the findings are not generalizable without limitations and instead represent non-exhaustive groundwork to enable a significant group of asset tokenization business models.

Additional limitations stem from primary data conducted in the various DSR cycles. Where the first and third artifacts focused on evaluation during the workshops of the CC Ecosystem, the participants may have found it difficult to verbalize feedback on the proposed research outcomes. On one side, the limited number of workshops, both in physical and virtual settings, has to be considered. On the other side, the members' varying knowledge about DLT and tokenization played a significant role. For that reason, additional interview studies and working groups with chosen experts were conducted.

While a theoretical saturation of new insights was consistently considered, the sample might lack heterogeneity and be subject to industry bias. Most experts worked in financial services and often associated use cases with the tokenization of bankable assets. Also, for the development of organizational principles, the opinion of a single representative may be too limited to explain the collective experience of an entire organization or even an industry. The empirical analysis of tokenization archetypes and the multiple case studies of the conceptual model may further limit the generalizability of the derived results, as the study is in some ways based on a snapshot of the current tokenization ecosystem.

Despite the efforts to conduct an objective interpretation of results, data analysis may be subject to the limitations of qualitative research approaches. For instance, there might be a contextual bias in screening,

analyzing, and refining results regarding thematic analysis and reference modeling. Nevertheless, the author's subjectivity was reduced due to regular discussion rounds with associated researchers.

In this context, it should be mentioned that the overall framework enables asset tokenization business models in the financial services sector. However, industry acceptance is yet to come, and practicality has yet to be proven. While the artifacts combine existing approaches, discussions about technicalities, such as formalized IT reference architectures, could be more detailed. Due to the highly dynamic legislation and the ever-changing technological landscape, the consistency of specific elements, terms, and definitions can not be fully ensured.

Future research should focus on empirical insights to investigate the different manifestations of the tokenization concept and identify additional elements of business models within a token economy. The assessment framework, for example, might be extended with additional metrics to further quantify the business potential in terms of a weighted sum model. In addition, selected tokenization archetypes, such as smart bankable assets, serve as a starting point for a more detailed investigation into entirely new services and products than those included in the dataset.

Applying the conceptual model using additional case studies or even longitudinal data will further capture various configurations of token-based businesses and illustrate, for instance, how different design decisions shape the overall asset tokenization network. Moreover, the identified elements provide the groundwork for research on patterns or design knowledge for operationalizing other DLT-based use cases or decentralized platforms. Further developments may also cover methodological support for a potential class of other models or formalized architectures with a higher degree of granularity, such as target operating models or DLT-based reference architectures.

While the organizational principles represent the first set of actionable guidelines to overcome difficulties in DTL implementation, additional

research on operational capabilities and best practices is appreciated. Based on the practical insights, it will be possible to specify additional solutions and prioritize the activities toward successful transformation. Especially, leadership and organizational culture might enable or accelerate this process in the financial services sector. In contrast, researchers can also apply the results to other sectors and industry-specific business functions. This research will be of interest to better understand the interrelationships between technical and political decentralization in the context of DLT and asset tokenization business models.

References

- Abreu, A. W. S., Coutinho, E. F., & Bezerra, C. I. M. (2020). A Blockchain-Based Architecture for Query and Registration of Student Degree Certificates. *Proceedings of the 14th Brazilian Symposium on Software Components, Architectures, and Reuse*, 151–160. <https://doi.org/10.1145/3425269.3425285>
- Adams, J., Khan, H., Raeside, R., & White, D. (2007). *Research Methods for Graduate Business and Social Science Students*. <https://doi.org/10.4135/9788132108498>
- Adner, R. (2016). Ecosystem as Structure: An Actionable Construct for Strategy. *Journal of Management*. <https://doi.org/10.1177/0149206316678451>
- Afuah, A., & Tucci, C. (2001). *Internet Business Models and Strategies*. Boston McGraw-Hill.
- Al-Debei, M., El-Haddadeh, R., & Avison, D. (2008). Defining the Business Model in the New World of Digital Business. *AMCIS*.
- Ali Syed, T., Alzahrani, A., Jan, S., Siddiqui, M. S., Nadeem, A., & Alghamdi, T. (2019). A Comparative Analysis of Blockchain Architecture and its Applications: Problems and Recommendations. *IEEE Access*, 7, 176838–176869. <https://doi.org/10.1109/ACCESS.2019.2957660>
- Allen, J. G., Rauchs, M., Blandin, A., & Bear, K. (2020). *Legal and Regulatory Considerations for Digital Assets* (p. 50). Cambridge Centre for Alternative Finance. <https://www.jbs.cam.ac.uk/wp-content/uploads/2020/10/2020-ccaf-legal-regulatory-considerations-report.pdf>
- Alsindi, W. Z., & Lotti, L. (2021). Mining. *Internet Policy Review*, 10(2). <https://doi.org/10.14763/2021.2.1551>
- Alt, R. (2008). Überbetriebliches Prozessmanagement: Gestaltungsalternativen und Vorgehen am Beispiel integrierter Prozessportale. In [Http://www.alexandria.unisg.ch/Publikationen/67400](http://www.alexandria.unisg.ch/Publikationen/67400).

- Alt, R. (2021). *Blockchain und Distributed-Ledger-Technologien: Infrastrukturen für die überbetriebliche Vernetzung*.
- Alt, R., Bernet, B., & Zerndt, T. (2009). *Transformation von Banken: Praxis des In- und Outsourcings auf dem Weg zur Bank 2015*. Springer-Verlag. <https://doi.org/10.1007/978-3-540-89834-4>
- Alt, R., & Legner, C. (2008). Business Networking. In S. Haeberle (Ed.), *Das neue Lexikon der Betriebswirtschaftslehre, Band A-E* (pp. 165–169). Oldenbourg. <https://www.alexandria.unisg.ch/213142/>
- Alt, R., & Zimmermann, H.-D. (2001). Preface: Introduction to Special Section - Business Models. *Electronic Markets*, 11. <https://doi.org/10.1080/713765630>
- Amit, R., & Zott, C. (2001). Value creation in E-business. *Strategic Management Journal*, 22(6–7), 493–520. <https://doi.org/10.1002/smj.187>
- Ankenbrand, T., & Bieri, D. (2018). Assessment of cryptocurrencies as an asset class by their characteristics. *Investment Management and Financial Innovations*, 15(3), 169–181. [https://doi.org/10.21511/imfi.15\(3\).2018.14](https://doi.org/10.21511/imfi.15(3).2018.14)
- Ankenbrand, T., Bieri, D., Cortivo, R., Hoehener, J., & Hardjono, T. (2020). Proposal for a Comprehensive (Crypto) Asset Taxonomy. *2020 Crypto Valley Conference on Blockchain Technology (CVCBT)*, 16–26. <https://doi.org/10.1109/CVCBT50464.2020.00006>
- Antal, C., Cioara, T., Anghel, I., Antal, M., & Salomie, I. (2021). Distributed Ledger Technology Review and Decentralized Applications Development Guidelines. *Future Internet*, 13(Tudor), 62. Coronavirus Research Database; Publicly Available Content Database. <https://doi.org/10.3390/fi13030062>
- Antonopoulos, A. M. (2014). *Mastering Bitcoin: Unlocking Digital Cryptocurrencies*. O'Reilly Media, Inc.
- Antonopoulos, A. M., & Wood, G. (2018). *Mastering Ethereum: Building Smart Contracts and Dapps* (1st ed.). O'Reilly UK Ltd.

- Atzei, N., Bartoletti, M., Cimoli, T., Lande, S., & Zunino, R. (2018). SoK: Unraveling Bitcoin Smart Contracts. In L. Bauer & R. Küsters (Eds.), *Principles of Security and Trust* (pp. 217–242). Springer International Publishing. https://doi.org/10.1007/978-3-319-89722-6_9
- Awa, H. O., Ojiabo, O. U., & Orokor, L. E. (2017). Integrated technology-organization-environment (T-O-E) taxonomies for technology adoption. *Journal of Enterprise Information Management*, 30(6), 893–921. <https://doi.org/10.1108/JEIM-03-2016-0079>
- Ayres, L. (2008). Semi-Structured Interview. In L. Given (Ed.), *The SAGE Encyclopedia of Qualitative Research Methods* (pp. 810–811). SAGE Publications, Inc. <https://doi.org/10.4135/9781412963909.n420>
- Babich, V., & Hilary, G. (2020). OM Forum—Distributed Ledgers and Operations: What Operations Management Researchers Should Know About Blockchain Technology. *Manufacturing & Service Operations Management*, 22(2), 223–240. <https://doi.org/10.1287/msom.2018.0752>
- Baker, J. (2012). The Technology–Organization–Environment Framework. In Y. K. Dwivedi, M. R. Wade, & S. L. Schneberger (Eds.), *Information Systems Theory: Explaining and Predicting Our Digital Society, Vol. 1* (pp. 231–245). Springer. https://doi.org/10.1007/978-1-4419-6108-2_12
- Baker, M. (2000). Writing a Literature Review. *The Marketing Review*, 1, 219–247. <https://doi.org/10.1362/1469347002529189>
- Baldwin, C., & Woodard, C. J. (2008). The Architecture of Platforms: A Unified View. *Platforms, Markets and Innovation*. <https://doi.org/10.2139/ssrn.1265155>
- Ballandies, M. C., Dapp, M. M., & Pournaras, E. (2021). Decrypting Distributed Ledger Design—Taxonomy, Classification and Blockchain Community Evaluation. *Cluster Computing*. <https://doi.org/10.1007/s10586-021-03256-w>
- Barnes, R. (2020, May 15). *Factors in the Portability of Tokenized Assets on Distributed Ledgers*.

- Bartunek, J. M., Rynes, S. L., & Ireland, R. D. (2006). What Makes Management Research Interesting, and Why Does It Matter? *The Academy of Management Journal*, 49(1), 9–15. JSTOR. <https://doi.org/10.2307/20159741>
- Bauer, I., Zavolokina, L., Leisibach, F., & Schwabe, G. (2019). Value Creation From a Decentralized Car Ledger. *Frontiers in Blockchain*. <https://doi.org/10.3389/fbloc.2019.00030>
- BBI. (2020). *Bundesgesetz zur Anpassung des Bundesrechts an Entwicklungen der Technik verteilter elektronischer Register* (BBI 2020 7801). <https://www.fedlex.admin.ch/eli/fga/2020/2007/de>
- Bear, K., Blandin, A., & Labetzsch, C. (2020). *Digital Asset Program*. 3rd Digital Asset Industry Forum. https://www.set.or.th/contactcenter/files/20191220_3rd_SET_IndustryForum_PUBLIC.pdf
- Beck, R., Avital, M., Rossi, M., & Thatcher, J. B. (2017). Blockchain Technology in Business and Information Systems Research. *Business & Information Systems Engineering*, 59(6), 381–384. <https://doi.org/10.1007/s12599-017-0505-1>
- Beck, R., Müller-Bloch, C., & King, J. L. (2018). Governance in the Blockchain Economy: A Framework and Research Agenda. *Journal of the Association for Information Systems*, 19(10), 1020–1034. <https://doi.org/10.17705/1jais.00518>
- Beckett, R., & Dalrymple, J. (2019). Business Model Architecture by Design. *Technology Innovation Management Review*, 7, 16–27. <https://doi.org/10.22215/timreview/1252>
- Bernet, B. (2003). *Institutionelle Grundlagen der Finanzintermediation* (p. 380). Vahlen. <https://www.alexandria.unisg.ch/12658/>
- Bertino, E., & Sandhu, R. (2005). Database security—Concepts, approaches, and challenges. *IEEE Transactions on Dependable and Secure Computing*, 2(1), 2–19. <https://doi.org/10.1109/TDSC.2005.9>
- BGBI. (2021). *Gesetz zur Einführung von elektronischen Wertpapieren* (BGBI. I S. 1423).

- https://www.bundesfinanzministerium.de/Content/DE/Gesetzestexte/Gesetze_Gesetzesvorhaben/Abteilungen/Abteilung_VII/19_Legislaturperiode/2021-06-09-einfuehrung-el-ektronische-wertpapiere/3-Verkuendetes-Gesetz.pdf?__blob=publicationFile&v=3
- Bhutta, M. N. M., Khwaja, A. A., Nadeem, A., Ahmad, H. F., Khan, M. K., Hanif, M. A., Song, H., Alshamari, M., & Cao, Y. (2021). A Survey on Blockchain Technology: Evolution, Architecture and Security. *IEEE Access*, 9, 61048–61073. <https://doi.org/10.1109/ACCESS.2021.3072849>
- BIAN. (2019, September 23). *BIAN Service Landscape V8.0*. Banking Industry Architecture Network (BIAN). https://bian.org/servicelandscape-8-0/views/view_27832.html
- Blémus, S., & Guegan, D. (2019). *Initial Crypto-asset Offerings (ICOs), tokenization and corporate governance*. 33.
- Bouraga, S. (2021). A taxonomy of blockchain consensus protocols: A survey and classification framework. *Expert Systems with Applications*, 168, N.PAG.
- Bouwman, H., Faber, E., & Spek, J. V. D. (2005). Connecting Future Scenarios to Business Models of Insurance Intermediaries. *Bled EConference*.
- Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77–101. <https://doi.org/10.1191/1478088706qp063oa>
- Braun, V., & Clarke, V. (2012). Thematic analysis. In *APA handbook of research methods in psychology, Vol 2: Research designs: Quantitative, qualitative, neuropsychological, and biological* (pp. 57–71). American Psychological Association. <https://doi.org/10.1037/13620-004>
- Bucherer, E. (2010). *Business Model Innovation—Guidelines for a Structured Approach*.

- Burgess, K. (2016, January 22). Bretton Woods White Paper. *Consumers' Research*. <https://consumersresearch.org/bretton-woods-white-paper/>
- Business Architecture Guild. (2019). *A Guide to the Business Architecture Body of Knowledge* (BIZBOK® Guide 7.5). Business Architecture Guild. https://cdn.ymaws.com/www.businessarchitectureguild.org/resource/resmgr/bizbok_8_5/bizbok_v8.5_final_part1.pdf
- Buterin, V. (2018). *Ethereum Whitepaper*. GitHub. <https://github.com/ethereum/wiki>
- Büyüközkan, G., & Tüfekçi, G. (2021). A decision-making framework for evaluating appropriate business blockchain platforms using multiple preference formats and VIKOR. *Information Sciences*, 571, 337–357. <https://doi.org/10.1016/j.ins.2021.04.044>
- Casino, F., Dasaklis, T. K., & Patsakis, C. (2019). A systematic literature review of blockchain-based applications: Current status, classification and open issues. *Telematics and Informatics*, 36, 55–81. <https://doi.org/10.1016/j.tele.2018.11.006>
- Castro, M., & Liskov, B. (2002). Practical byzantine fault tolerance and proactive recovery. *TOCS*. <https://doi.org/10.1145/571637.571640>
- Catalini, C., & Gans, J. S. (2020). Some simple economics of the blockchain. *Communications of the ACM*, 63(7), 80–90. <https://doi.org/10.1145/3359552>
- Cen, Y., Wang, H., & Li, X. (2017). Improving Business Process Interoperability by Shared Ledgers. *Proceedings of the 6th International Conference on Informatics, Environment, Energy and Applications*, 89–93. <https://doi.org/10.1145/3070617.3070631>
- Chaum, D. (1985). Security without identification: Transaction systems to make big brother obsolete. *Communications of the ACM*, 28(10), 1030–1044. <https://doi.org/10.1145/4372.4373>

- Che, Z., Wang, Y., Zhao, J., Qiang, Y., Ma, Y., & Liu, J. (2019). A Distributed Energy Trading Authentication Mechanism Based on a Consortium Blockchain. *Energies* (19961073), 12(15), 2878.
- Chen, Y. (2018). Blockchain tokens and the potential democratization of entrepreneurship and innovation. *Business Horizons*, 61(4), 567–575. <https://doi.org/10.1016/j.bushor.2018.03.006>
- Chesbrough, H. (2010). Business Model Innovation: Opportunities and Barriers. *Long Range Planning*, 43(2), 354–363. <https://doi.org/10.1016/j.lrp.2009.07.010>
- Chiu, S. H., & Shang, S. (2019). Can Blockchain Really Remove All Intermediaries? A Multiple-Case Study in Different Industries. *International Conference on Information Systems Development (ISD)*. <https://aisel.aisnet.org/isd2014/proceedings2019/CurrentTopics/3>
- Choudhury, R., & Weisman, B. (2021). *Digital Assets, Distributed Ledger Technology, and the Future of Capital Markets*. The World Economic Forum. http://www3.weforum.org/docs/WEF_Digital_Assets_Distributed_Ledger_Technology_2021.pdf
- Cœuré, B., Bech, M. L., Bank für Internationalen Zahlungsausgleich, Schweizerische Nationalbank, & SIX Group. (2020). *Project Helvetia: Settling tokenised assets in central bank money*. <https://www.bis.org/publ/othp35.pdf>
- Collins, P. D., Hage, J., & Hull, F. M. (1988). Organizational and Technological Predictors of Change in Automaticity. *The Academy of Management Journal*, 31(3), 512–543. <https://doi.org/10.2307/256458>
- Collomb, A., & Sok, K. (2016). Blockchain / Distributed Ledger Technology (DLT): What Impact on the Financial Sector? *DigiWorld Economic Journal*, 103, 93–111.
- Comes, S., & Berniker, L. (2008). Business Model Innovation. In D. Pantaleo & N. Pal (Eds.), *From Strategy to Execution: Turning Accelerated Global Change into Opportunity* (pp. 65–86). Springer. https://doi.org/10.1007/978-3-540-71880-2_4

- Connolly, T. M., & Begg, C. E. (2005). *Database Systems: A Practical Approach to Design, Implementation, and Management*. Pearson Education.
- Conway, D., & Garimella, K. (2020). Enhancing Trust in Business Ecosystems With Blockchain Technology. *IEEE Engineering Management Review*, 48(1), 24–30. <https://doi.org/10.1109/EMR.2020.2970387>
- Cooper, H. (1988). Organizing knowledge syntheses: A taxonomy of literature reviews. *Knowledge in Society*, 1, 104–126. <https://doi.org/10.1007/BF03177550>
- CPMI. (2014). *Principles for Financial Market Infrastructures (PFMI)*. Bank for International Settlements. https://www.bis.org/cpmi/info_pfmi.htm
- de Kruijff, J., & Weigand, H. (2017). Understanding the Blockchain Using Enterprise Ontology. In E. Dubois & K. Pohl (Eds.), *Advanced Information Systems Engineering* (pp. 29–43). Springer International Publishing. https://doi.org/10.1007/978-3-319-59536-8_3
- De Rossi, L. M., Abbatemarco, N., & Salviotti, G. (2019). Towards a Comprehensive Blockchain Architecture Continuum. *Hawaii International Conference on System Sciences 2019 (HICSS-52)*. <https://aisel.aisnet.org/hicss-52/in/blockchain/9>
- Deloitte Legal. (2018). *Blockchain: Legal implications, questions, opportunities and risks*.
- Demil, B., & Lecocq, X. (2010). Business Model Evolution: In Search of Dynamic Consistency. *Long Range Planning*, 43(2), 227–246. <https://doi.org/10.1016/j.lrp.2010.02.004>
- Depietro, R., Wiarda, E., & Fleischer, M. (1990). The context for change: Organization, technology and environment. *The Processes of Technological Innovation*, 199(0), 151–175.
- Deubel, M., Moormann, J., & Holotiuk, F. (2017). Nutzung der Blockchain-Technologie in Geschäftsprozessen: Analyse am Beispiel des Zahlungsverkehrs. *GI-Jahrestagung*. https://doi.org/10.18420/in2017_82

- Dietz, J. (2006). The deep structure of business processes. *Communications of the ACM*, 49(5), 58–64. <https://doi.org/10.1145/1125944.1125976>
- Dinh, T. T. A., Liu, R., Zhang, M., Chen, G., Ooi, B. C., & Wang, J. (2018). Untangling Blockchain: A Data Processing View of Blockchain Systems. *IEEE Transactions on Knowledge and Data Engineering*, 30(7), 1366–1385. <https://doi.org/10.1109/TKDE.2017.2781227>
- Distefano, B., Pocher, N., & Zichichi, M. (2020). MOATcoin: Exploring challenges and legal implications of smart contracts through a gamelike DApp experiment. *Proceedings of the 3rd Workshop on Cryptocurrencies and Blockchains for Distributed Systems*, 53–58. <https://doi.org/10.1145/3410699.3413798>
- Du, M., Chen, Q., Xiao, J., Yang, H., & Ma, X. (2020). Supply Chain Finance Innovation Using Blockchain. *IEEE Transactions on Engineering Management*, 67(4), 1045–1058.
- Du, X., Qi, Y., Chen, B., Shan, B., & Liu, X. (2021). The Integration of Blockchain Technology and Smart Grid: Framework and Application. *Mathematical Problems in Engineering*, 1–12.
- Dubé, L., & Paré, G. (2003). Rigor in Information Systems Positivist Case Research: Current Practices, Trends, and Recommendations. *MIS Quarterly*, 27(4), 597–636. <https://doi.org/10.2307/30036550>
- Eickhoff, M., Muntermann, J., & Weinrich, T. (2017). What do FinTechs actually do? A Taxonomy of FinTech Business Models. *Thirty Eighth International Conference on Information Systems*. International Conference on Information Systems.
- Eisenhardt, K. M., & Graebner, M. E. (2007). Theory Building From Cases: Opportunities And Challenges. *Academy of Management Journal*, 50(1), 25–32. <https://doi.org/10.5465/amj.2007.24160888>
- Euler, T. (2018, January 18). The Token Classification Framework: A multi-dimensional tool for understanding and classifying crypto tokens. – Untitled INC. *Untitled INC*. <http://www.untitled->

- inc.com/the-token-classification-framework-a-multi-dimensional-tool-for-understanding-and-classifying-crypto-tokens/
- Eurostat. (2020). *Cloud computing—Statistics on the use by enterprises*. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Cloud_computing_-_statistics_on_the_use_by_enterprises
- Ferreira, A., Sandner, P. G., & Dünser, T. (2021). Cryptocurrencies, DLT and Crypto Assets – the Road to Regulatory Recognition in Europe. *Forthcoming in: Handbook on Blockchain*. <https://doi.org/10.2139/ssrn.3891401>
- Fettke, P., & Loos, P. (2005). Der Beitrag der Referenzmodellierung zum Business Engineering. *Johannes Gutenberg-Universität Mainz - Lehrstuhl für Wirtschaftsinformatik und BWL - Publikationen*.
- FINMA. (2018). *FINMA publishes ICO guidelines*. Eidgenössische Finanzmarktaufsicht FINMA. <https://www.finma.ch/en/news/2018/02/20180216-mm-ico-wegleitung/>
- Frankenberger, K., Weiblen, T., cSik, M. cSamil, & Gassmann, O. (2013). The 4I-framework of business model innovation: A structured view on process phases and challenges. *International Journal of Product Development*, 18(3), 249–273. <https://doi.org/10.1504/IJPD.2013.055012>
- Freni, P., Ferro, E., & Moncada, R. (2020). Tokenization and Blockchain Tokens Classification: A morphological framework. *2020 IEEE Symposium on Computers and Communications*, 1–6.
- Fridgen, G., Guggenberger, N., Hoeren, T., Prinz, W., Urbach, N., Baur, J., Brockmeyer, H., Gräther, W., Rabovskaja, E., Schlatt, V., Schweizer, A., Sedlmeir, J., & Wederhake, L. (2019). *Chancen und Herausforderungen von DLT (Blockchain) in Mobilität und Logistik*. <https://www.fim-rc.de/Paperbibliothek/Veroeffentlich/1106/wi-1106.pdf>
- Fridgen, G., Radszuwill, S., Urbach, N., & Utz, L. (2018). Cross-Organizational Workflow Management Using Blockchain Technology—

- Towards Applicability, Auditability, and Automation. *HICSS*. <https://doi.org/10.24251/HICSS.2018.444>
- GVTG, 301, Fürstentum Liechtenstein - Gesetz über Token und VT-Dienstleister, 2019.301 (2019). <https://www.gesetze.li/konso/2019301000>
- Gassmann, O., Frankenberger, K., & Csik, M. (2017). *Geschäftsmodelle entwickeln: 55 innovative Konzepte mit dem St. Galler Business Model Navigator* (p. I–XIV). <https://doi.org/10.3139/9783446452848.fm>
- Geissdoerfer, M., Savaget, P., & Evans, S. (2017). The Cambridge Business Model Innovation Process. *Procedia Manufacturing*, 8, 262–269. <https://doi.org/10.1016/j.promfg.2017.02.033>
- Ghahramany Dehbokry, S., & Chew, E. K. (2014). *The Strategic Requirements for an Enterprise Business Architecture Framework by SMEs*. <https://opus.lib.uts.edu.au/handle/10453/41041>
- Gharajedaghi, J. (2011). Business Architecture. In J. Gharajedaghi (Ed.), *Systems Thinking (Third Edition)* (pp. 181–207). Morgan Kaufmann. <https://doi.org/10.1016/B978-0-12-385915-0.00009-X>
- Gioia, D. A., Corley, K., & Hamilton, A. L. (2013). Seeking Qualitative Rigor in Inductive Research: Notes on the Gioia Methodology. *Organizational Research Methods*, 16(1), 15–31. <https://doi.org/10.1177/1094428112452151>
- Giraldo, J. (2018). X-BORDER PLATFORMS: THE IMPLICATIONS OF DISTRIBUTED LEDGER TECHNOLOGY. *Research Papers*. https://aisel.aisnet.org/ecis2018_rp/70
- Glaser, F. (2017). Pervasive Decentralisation of Digital Infrastructures: A Framework for Blockchain enabled System and Use Case Analysis. *Hawaii International Conference on System Sciences 2017 (HICSS-50)*. https://aisel.aisnet.org/hicss-50/da/open_digital_services/4
- Glaser, F., & Bezenberger, L. (2015, May 29). Beyond Cryptocurrencies—A Taxonomy of Decentralized Consensus Systems. *ECIS*

- 2015 Completed Research Papers*. European Conference on Information Systems. <https://doi.org/10.18151/7217326>
- Gorden, R. L. (1975). *Interviewing: Strategy, techniques, and tactics* (Rev. ed). Dorsey Press.
- Greer, R. J. (1997). What is an Asset Class, Anyway? *The Journal of Portfolio Management*, 23(2), 86–91. <https://doi.org/10.3905/jpm.23.2.86>
- Gregor, S., & Hevner, A. (2013). Positioning and Presenting Design Science Research for Maximum Impact. *Management Information Systems Quarterly*, 37(2), 337–355.
- Grilo, A., & Zutshi, A. (2020). Preface for special issue on blockchain and tokenization for industry and services. *Computers & Industrial Engineering*, 146, N.PAG-N.PAG. <https://doi.org/10.1016/j.cie.2020.106575>
- Guadamillas, M., & Keppler, R. (2001). *Securities Clearance and Settlement Systems: A Guide to Best Practices*. World Bank. <https://doi.org/10.1596/1813-9450-2581>
- Guadamuz, A. (2019). All watched over by machines of loving grace: A critical look at smart contracts. *Computer Law & Security Review*, 35(6), N.PAG-N.PAG. <https://doi.org/10.1016/j.clsr.2019.105338>
- Guest, G., MacQueen, K. M., & Namey, E. E. (2011). *Applied Thematic Analysis*. SAGE Publications.
- Guggenberger, T., Stoetzer, J.-C., Theisinger, L., Amend, J., & Urbach, N. (2021). You Can't Manage What You Can't Define: The Success of Blockchain Projects Beyond the Iron Triangle. *ICIS 2021 Proceedings*. <https://aisel.aisnet.org/icis2021/fintech/fintech/3>
- Haber, S., & Stornetta, W. S. (1991). How to time-stamp a digital document. *Journal of Cryptology*, 3(2), 99–111. <https://doi.org/10.1007/BF00196791>
- Hakansson, H., & Snehota, I. (1994). *Developing Relationships in Business Networks*. Cengage Learning EMEA.

- Haki, M. K., & Forte, M. W. (2010). Inter-Organizational Information System Architecture: A Service-Oriented Approach. In L. M. Camarinha-Matos, X. Boucher, & H. Afsarmanesh (Eds.), *Collaborative Networks for a Sustainable World* (Vol. 336, pp. 642–652). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-15961-9_77
- Han, X., Yuan, Y., & Wang, F.-Y. (2019). A Blockchain-based Framework for Central Bank Digital Currency. *2019 IEEE International Conference on Service Operations and Logistics, and Informatics (SOLI)*, 263–268. <https://doi.org/10.1109/SOLI48380.2019.8955032>
- Hartung, G., Rutter, K., & Stroemer, G. (2019). A solution for managing high-quality liquid assets: How distributed ledger technology can benefit the securities lending market. *Journal of Securities Operations & Custody*, 11.
- Harwood-Jones, M. (2019). Digital and crypto-assets: Tracking global adoption rates and impacts on securities services. *Journal of Securities Operations & Custody*, 10.
- Hedman, J., & Kalling, T. (2003). Kalling, T.: The business model concept: Theoretical underpinnings and empirical illustrations. *European Journal of Information Systems* 12(1), 49-59. *European Journal of Information Systems*, 12, 49–53. <https://doi.org/10.1057/palgrave.ejis.3000446>
- Heines, R., Dick, C., Pohle, C., & Jung, R. (2021, July 12). The Tokenization of Everything: Towards a Framework for Understanding the Potentials of Tokenized Assets. *PACIS 2021 Proceedings*. <https://aisel.aisnet.org/pacis2021/40>
- Heines, R., & Guerpinar, T. (2021). Towards a Typology of Blockchain-based Applications: A Conceptualization from a Business Perspective. *Konferenzband Zum Scientific Track Der Blockchain Autumn School 2021*, 4.
- Heines, R., Kannengießer, N., Sturm, B., Jung, R., & Sunyaev, A. (2021). Need for Change: Business Functions Affected by the Use of Decentralized Information Systems. *International Conference*

- on Information Systems 2021 Proceedings*. International Conference on Information Systems 2021, Austin, Texas, USA.
- Henning, M. (2018). *Custody of crypto assets—The challenge to securely store and operationalize private keys*. Frankfurt School Blockchain Center Forum, Frankfurt.
- Henriette, E., Feki, M., & Boughzala, I. (2016). Digital Transformation Challenges. *MCIS 2016 Proceedings*. <https://aisel.aisnet.org/mcis2016/33>
- Hevner, A. (2007). A Three Cycle View of Design Science Research. *Scandinavian Journal of Information Systems*, 19(2). <https://aisel.aisnet.org/sjis/vol19/iss2/4>
- Hevner, A., Park, J., & Ram, S. (2004). Design Science in Information Systems Research. *MIS Quarterly*, 28(1), 32.
- Hirtschulz, M., Henning, M., Valovich, F., Resas, D., & Ulrich, N. (2019). *Neue Blockchain-basierte Marktinfrastrukturen: Digital Asset Custody* (Rethinking Finance). https://beisg-my.sharepoint.com/personal/roger_heines_bei-sg_ch/Documents/Microsoft%20Teams-Chatdateien/Neue_Blockchain-basierte_Marktinfrastrukturen_Digital_Asset_Custody_Matthias_Hirtschulz.pdf
- Homoliak, I., Venugopalan, S., Reijdsbergen, D., Hum, Q., Schumi, R., & Szalachowski, P. (2021). The Security Reference Architecture for Blockchains: Toward a Standardized Model for Studying Vulnerabilities, Threats, and Defenses. *IEEE Communications Surveys Tutorials*, 23(1), 341–390. <https://doi.org/10.1109/COMST.2020.3033665>
- Hrga, A., Capuder, T., & Žarko, I. P. (2020). Demystifying Distributed Ledger Technologies: Limits, Challenges, and Potentials in the Energy Sector. *IEEE Access*, 8, 126149–126163. <https://doi.org/10.1109/ACCESS.2020.3007935>
- Hughes, L., Dwivedi, Y. K., Misra, S. K., Rana, N. P., Raghavan, V., & Akella, V. (2019). Blockchain research, practice and policy: Applications, benefits, limitations, emerging research themes and research agenda. *International Journal of Information Management*, 49, 114–129. <https://doi.org/10.1016/j.jinfomgt.2019.02.005>

- InterWork Alliance IWA. (2020, May). *Token Taxonomy Framework Overview TTF*. GitHub. <https://github.com/InterWorkAlliance/TokenTaxonomyFramework>
- Ismail, L., & Materwala, H. (2019). A Review of Blockchain Architecture and Consensus Protocols: Use Cases, Challenges, and Solutions. *Symmetry* (20738994), 11(10), 1198.
- ISO 21188. (2018). ISO. <https://www.iso.org/cms/render/live/en/sites/isoorg/contents/data/standard/06/31/63134.html>
- ISO 22739. (2020). ISO. <https://www.iso.org/cms/render/live/en/sites/isoorg/contents/data/standard/07/37/73771.html>
- Jayasuriya, D., & Sims, A. (2021). Fantastic Beasts: Blockchain Based Banking. *Journal of Risk and Financial Management*, 14(4), 170. Coronavirus Research Database; Publicly Available Content Database. <https://doi.org/10.3390/jrfm14040170>
- Johnson, M. W., Christensen, C. M., & Kagermann, H. (2008). Reinventing your business model. *Harvard Business Review: HBR*, 86(12).
- Jung, R. (2006). *Architekturen zur Datenintegration: Gestaltungsempfehlungen auf der Basis fachkonzeptueller Anforderungen*. Springer-Verlag.
- Kannengießer, N., Lins, S., Dehling, T., & Sunyaev, A. (2020). Trade-offs between Distributed Ledger Technology Characteristics. *ACM Computing Surveys*, 53(2), 1–37. <https://doi.org/10.1145/3379463>
- Kannengiesser, N., Lins, S., Sander, C., Winter, K., Frey, H., & Sunyaev, A. (2021). Challenges and Common Solutions in Smart Contract Development. *IEEE Transactions on Software Engineering*, 1–1. <https://doi.org/10.1109/TSE.2021.3116808>
- Kannengießer, N., Lins, S., & Sunyaev, A. (2020). Uncertainties toward Permissioned Distributed Ledgers: A Multi-Actor uncertainty Conceptualization. *ECIS 2020 Research Papers*. https://aisel.aisnet.org/ecis2020_rp/205

- Kaur, E., & Oza, A. (2020). Blockchain-based multi-organization taxonomy for smart cities. *SN Applied Sciences*, 2(3), 440. <https://doi.org/10.1007/s42452-020-2187-4>
- Ketz, C., & Sandner, P. (2019, July 16). Market standards for the global token economy—International Token Standardization Association. *Medium*. https://medium.com/@itsa_global/market-standards-for-the-global-token-economy-7d9f3d0cde37
- Khan, N., Kchouri, B., Yattoo, N. A., Kräussl, Z., Patel, A., & State, R. (2020). Tokenization of sukuk: Ethereum case study. *Global Finance Journal*, 100539. <https://doi.org/10.1016/j.gfj.2020.100539>
- Khemani, R. S., & Shapiro, D. M. (1993). *Glossary of industrial organization economics and competition law*. Paris : Centre for Co-operation with the Europ. Economies in Transition.
- Kim, S. (2020). Fractional Ownership, Democratization and Bubble Formation—The Impact of Blockchain Enabled Asset Tokenization. *AMCIS 2020 Proceedings*, 6.
- Knauer, F., & Mann, A. (2020). What is in It for Me? Identifying Drivers of Blockchain Acceptance among German Consumers. *The Journal of the British Blockchain Association*, 3(1), 1–16. [https://doi.org/10.31585/jbba-3-1-\(1\)2020](https://doi.org/10.31585/jbba-3-1-(1)2020)
- Köhne, T. (2006). *Marketing im strategischen Unternehmensnetzwerk: Erklärungsmodell und praktische Anwendung in der Versicherungswirtschaft*. Deutscher Universitätsverlag. <https://doi.org/10.1007/978-3-8350-9287-7>
- Kuan, K. K. Y., & Chau, P. Y. K. (2001). A perception-based model for EDI adoption in small businesses using a technology–organization–environment framework. *Information & Management*, 38(8), 507–521. [https://doi.org/10.1016/S0378-7206\(01\)00073-8](https://doi.org/10.1016/S0378-7206(01)00073-8)
- Kwon, I.-W. G., & Suh, T. (2004). Factors Affecting the Level of Trust and Commitment in Supply Chain Relationships. *Journal of Supply Chain Management*, 40(1), 4–14. <https://doi.org/10.1111/j.1745-493X.2004.tb00165.x>

- Labazova, O. (2019). Towards a Framework for Evaluation of Blockchain Implementations. *ICIS 2019 Proceedings*. https://aisel.aisnet.org/icis2019/blockchain_fintech/blockchain_fintech/18
- Labazova, O., Dehling, T., & Sunyaev, A. (2018). *From Hype to Reality: A Taxonomy of Blockchain Applications*. <https://papers.ssrn.com/abstract=3250648>
- Lacity, M. (2018). Addressing Key Challenges to Making Enterprise Blockchain Applications a Reality. *MIS Quarterly Executive*, 17(3), Article 3. <https://aisel.aisnet.org/misqe/vol17/iss3/3>
- Lai, A., Pang, P., Lee, E., Murphy, J., & Jack, W. G. (2021). *Tokenisation of Alternative Investments*. CAIA. https://caia.org/sites/default/files/2021-02/CAIA_Tokenisation_of_Alternatives.pdf
- Lamport, L., Shostak, R., & Pease, M. C. (1982). The Byzantine Generals Problem. *ACM Trans. Program. Lang. Syst.* <https://doi.org/10.1145/357172.357176>
- Lao, L., Li, Z., Hou, S., Xiao, B., Guo, S., & Yang, Y. (2020). A Survey of IoT Applications in Blockchain Systems: Architecture, Consensus, and Traffic Modeling. *ACM Comput. Surv.*, 53(1). <https://doi.org/10.1145/3372136>
- Latif, S., Idrees, Z., Ahmad, J., Zheng, L., & Zou, Z. (2021). A blockchain-based architecture for secure and trustworthy operations in the industrial Internet of Things. *Journal of Industrial Information Integration*, 21, 100190. <https://doi.org/10.1016/j.jii.2020.100190>
- Levin, S. G., Levin, S. L., & Meisel, J. B. (1987). A Dynamic Analysis of the Adoption of a New Technology: The Case of Optical Scanners. *The Review of Economics and Statistics*, 69(1), 12–17. <https://doi.org/10.2307/1937895>
- Li, X., Wu, X., Pei, X., & Yao, Z. (2019). Tokenization: Open Asset Protocol on Blockchain. *2019 IEEE 2nd International Conference on Information and Computer Technologies (ICICT)*, 204–209. <https://doi.org/10.1109/INFOCT.2019.8711021>

- Li, X., Zheng, Z., & Dai, H.-N. (2021). When services computing meets blockchain: Challenges and opportunities. *Journal of Parallel & Distributed Computing*, 150, 1–14.
- Li, Y. (2008). An empirical investigation on the determinants of e-procurement adoption in Chinese manufacturing enterprises. *2008 International Conference on Management Science and Engineering 15th Annual Conference Proceedings*, 32–37. <https://doi.org/10.1109/ICMSE.2008.4668890>
- Lin, T. C. W. (2015). Infinite Financial Intermediation. *Wake Forest Law Review*, 50(3).
- Liu, Y., Lu, Q., Zhu, L., Paik, H., & Staples, M. (2021). A Systematic Literature Review on Blockchain Governance. *ArXiv*.
- Lotti, L. (2019). The Art of Tokenization: Blockchain Affordances and the Invention of Future Milieus. *Media Theory*, 3(1), 287–320.
- Lu, Q., Tran, A. B., Weber, I., O'Connor, H., Rimba, P., Xu, X., Staples, M., Zhu, L., & Jeffery, R. (2021). Integrated model-driven engineering of blockchain applications for business processes and asset management. *Software: Practice and Experience*, 51(5), 1059–1079. <https://doi.org/10.1002/spe.2931>
- Lu, Q., Xu, X., Liu, Y., Weber, I., Zhu, L., & Zhang, W. (2019). UBaaS: A unified blockchain as a service platform. *Future Generation Computer Systems*, 101, 564–575.
- Macedo, J. M. (2019, May 28). A taxonomy of token models and valuation methodologies. *Medium*. <https://medium.com/amazix/a-taxonomy-of-token-models-and-valuation-methodologies-7b6c0a1d02a9>
- Mackey, T. K., Kuo, T.-T., Gummadi, B., Clauson, K. A., Church, G., Grishin, D., Obbad, K., Barkovich, R., & Palombini, M. (2019). 'Fit-for-purpose?'—Challenges and opportunities for applications of blockchain technology in the future of healthcare. *BMC Medicine*, 17(1), N.PAG.
- Madhwal, Y. (2020). Implementation of Tokenised Supply Chain Using Blockchain Technology. *2020 IEEE 21st International Symposium*

- on "A World of Wireless, Mobile and Multimedia Networks" (WoWMoM), 66–67. <https://doi.org/10.1109/WoWMoM49955.2020.00026>
- Mahadevan, B. (2000). Business Models for Internet-Based E-Commerce: An Anatomy. *California Management Review*, 42(4), 55–69. <https://doi.org/10.2307/41166053>
- Mainelli, M., & Milne, A. (2016). *The Impact and Potential of Blockchain on the Securities Transaction Lifecycle* (SSRN Scholarly Paper ID 2777404). Social Science Research Network. <https://papers.ssrn.com/abstract=2777404>
- March, S. T., & Smith, G. F. (1995). Design and natural science research on information technology. *Decision Support Systems*, 15(4), 251–266. [https://doi.org/10.1016/0167-9236\(94\)00041-2](https://doi.org/10.1016/0167-9236(94)00041-2)
- Marshall, L., Repin, A., Tsaviris, C., & Humberstones, C. (2018). *CryptoCompare Cryptoasset Taxonomy*. CryptoCompare.
- Mazzei, D., Baldi, G., Fantoni, G., Montelisciani, G., Pitasi, A., Ricci, L., & Rizzello, L. (2020). A Blockchain Tokenizer for Industrial IOT trustless applications. *Future Generation Computer Systems*, 105, 432–445.
- McFarlane, D., Sarma, S., Chirn, J. L., Wong, C. Y., & Ashton, K. (2003). Auto ID systems and intelligent manufacturing control. *Engineering Applications of Artificial Intelligence*, 16(4), 365–376. [https://doi.org/10.1016/S0952-1976\(03\)00077-0](https://doi.org/10.1016/S0952-1976(03)00077-0)
- Meijer, C. R. W. de. (2020). The roles of CSDs in a blockchain environment. *Journal of Securities Operations & Custody*, 12(2), 167–174.
- Mendling, J., Weber, I., Aalst, W. V. D., Brocke, J. V., Cabanillas, C., Daniel, F., Debois, S., Ciccio, C. D., Dumas, M., Dustdar, S., Gal, A., García-Bañuelos, L., Governatori, G., Hull, R., Rosa, M. L., Leopold, H., Leymann, F., Recker, J., Reichert, M., ... Zhu, L. (2018). Blockchains for Business Process Management—Challenges and Opportunities. *ACM Transactions on Management Information Systems*, 9(1), 1–16. <https://doi.org/10.1145/3183367>

- Merton, R. C. (1995). A Functional Perspective of Financial Intermediation. *Financial Management*, 24(2), 23–41. <https://doi.org/10.2307/3665532>
- Meuser, M., & Nagel, U. (2009). Das Experteninterview—Konzeptionelle Grundlagen und methodische Anlage. In S. Pickel, G. Pickel, H.-J. Lauth, & D. Jahn (Eds.), *Methoden der vergleichenden Politik- und Sozialwissenschaft: Neue Entwicklungen und Anwendungen* (pp. 465–479). VS Verlag für Sozialwissenschaften. https://doi.org/10.1007/978-3-531-91826-6_23
- Millard, C. (2018). Blockchain and law: Incompatible codes? *Computer Law & Security Review*, 34(4), 843–846. <https://doi.org/10.1016/j.clsr.2018.06.006>
- Mohsen, W., Aref, M., & ElBahnasy, K. (2020). Blockchain as a Platform for Collaborative Ontology Evolution. *Proceedings of the 2020 The 6th International Conference on Frontiers of Educational Technologies*, 183–190. <https://doi.org/10.1145/3404709.3404769>
- Moin, S., Karim, A., Safdar, Z., Safdar, K., Ahmed, E., & Imran, M. (2019). Securing IoTs in distributed blockchain: Analysis, requirements and open issues. *Future Generation Computer Systems*, 100, 325–343.
- Mooney, A. (2018, February 22). *Blockchain ‘could save asset managers \$2.7bn a year.’* <https://www.ft.com/content/b6171016-171f-11e8-9e9c-25c814761640>
- Moore, J. F. (1993). Predators and prey: A new ecology of competition. *Harvard Business Review*, 71(3), 75–86.
- Morgan, D. L. (1997). *Focus groups as qualitative research*, 2nd ed (pp. viii, 80). Sage Publications, Inc. <https://doi.org/10.4135/9781412984287>
- Morgan, D. L., & Krueger, R. A. (1993). When to use focus groups and why. In *Successful focus groups: Advancing the state of the art* (pp. 3–19). Sage Publications, Inc. <https://doi.org/10.4135/9781483349008.n1>

- Morris, M., Schindehutte, M., & Allen, J. (2005). The Entrepreneur's Business Model: Toward a Unified Perspective. *Journal of Business Research*, 58, 726–735. <https://doi.org/10.1016/j.jbusres.2003.11.001>
- Morris, M., Schindehutte, M., Richardson, J., & Allen, J. (2006). Is the Business Model a Useful Strategic Concept? Conceptual, Theoretical, and Empirical Insights. *Journal of Small Business Strategy*, 17(1), 27–50.
- Morton, M. S., & Thurow, L. C. (1990). *Corporation of the 1990s: Information Technology and Organizational Transformation*. Oxford University Press, Inc.
- Mougayar, W., & Vitalik, B. (2016). *The Business Blockchain: Promise, Practice, and Application of the Next Internet Technology* | Wiley. Wiley. <https://www.wiley.com/en-us/The+Business+Blockchain%3A+Promise%2C+Practice%2C+and+Application+of+the+Next+Internet+Technology-p-9781119300311>
- Mueller, L., Glarner, Linder, & Meyer. (2018). *BCP Framework for Assessment of Crypto Tokens—MME - Blockchain Crypto Property*.
- Nakamoto, S. (2008). *Bitcoin: A Peer-to-Peer Electronic Cash System* (Original Whitepaper). Manubot.
- Nanayakkara, S., Rodrigo, M. N. N., Perera, S., Weerasuriya, G. T., & Hijazi, A. A. (2021). A methodology for selection of a Blockchain platform to develop an enterprise system. *Journal of Industrial Information Integration*, 23, 100215. <https://doi.org/10.1016/j.jii.2021.100215>
- Naqvi, N. (2020). Evidence-Based Blockchain: Findings from a Global Study of Blockchain Projects and Start-up Companies. *The Journal of The British Blockchain Association*, 3(2), 1–13. [https://doi.org/10.31585/jbba-3-2-\(8\)2020](https://doi.org/10.31585/jbba-3-2-(8)2020)
- Narayan, R., & Tidström, A. (2020). Tokenizing coopetition in a blockchain for a transition to circular economy. *Journal of Cleaner Production*, 263, 121437. <https://doi.org/10.1016/j.jclepro.2020.121437>

- Normann, R., & Ramírez, R. (1993). From value chain to value constellation: Designing interactive strategy. *Harvard Business Review*, 71(4), 65–77.
- Notheisen, B., Hawlitschek, F., & Weinhardt, C. (2017). BREAKING DOWN THE BLOCKCHAIN HYPE – TOWARDS A BLOCKCHAIN MARKET ENGINEERING APPROACH. *Research Papers*, 1062–1080.
- Notheisen, B., Willrich, S., Diez, M., & Weinhardt, C. (2019). Requirement-driven Taxonomy Development—A Classification of Blockchain Technologies for Securities Post-Trading. *HICSS*. <https://doi.org/10.24251/HICSS.2019.558>
- OECD. (2020). *The Tokenisation of Assets and Potential Implications for Financial Markets* (OECD Blockchain Policy Series). OECD. <https://www.oecd.org/finance/The-Tokenisation-of-Assets-and-Potential-Implications-for-Financial-Markets.pdf>
- Okada, H., Yamasaki, S., & Bracamonte, V. (2017). Proposed classification of blockchains based on authority and incentive dimensions. *2017 19th International Conference on Advanced Communication Technology (ICACT)*, 593–597. <https://doi.org/10.23919/ICACT.2017.7890159>
- Oliveira, L., Zavolokina, L., Bauer, I., & Schwabe, G. (2018). *To Token or not to Token: Tools for Understanding Blockchain Tokens*. In: International Conference of Information Systems. <https://doi.org/10.5167/UZH-157908>
- Oliveira, T., & Martins, M. R. (2011). Literature Review of Information Technology Adoption Models at Firm Level. 1566-6379, 14.
- Omran, Y., Henke, M., Heines, R., & Hofmann, E. (2017). Blockchain-driven supply chain finance: Towards a conceptual framework from a buyer perspective. *26th Annual IPSERA Conference 2017*. IPSERA. <https://www.semanticscholar.org/paper/Blockchain-driven-supply-chain-finance%3A-Towards-a-a-Omran-Henke/71921ada84a60f1f3e326ca1fc4fa9dc5ea8007c>
- Österle, H. (1995). *Business Engineering. Prozeß- und Systementwicklung* (1st ed.). Springer-Verlag.

- Österle, H., Hoening, F., & Osl, P. (2011). *Methodenkern des Business Engineering—Ein Lehrburch*. <https://www.alexandria.unisg.ch/publications/215432>
- Österle, H., & Otto, B. (2010). Consortium Research. *Business & Information Systems Engineering*, 2(5), 283–293. <https://doi.org/10.1007/s12599-010-0119-3>
- Österle, H., & Winter, R. (2003). Business Engineering. In H. Österle & R. Winter (Eds.), *Business Engineering: Auf dem Weg zum Unternehmen des Informationszeitalters* (pp. 3–19). Springer. https://doi.org/10.1007/978-3-642-19003-2_1
- Osterwalder, A. (2004). *The Business Model Ontology – A Proposition in a Design Science Approach*.
- Osterwalder, A., & Pigneur, Y. (2010). *Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers*. John Wiley & Sons.
- Osterwalder, A., Pigneur, Y., & Tucci, C. L. (2005). Clarifying Business Models: Origins, Present, and Future of the Concept. *Communications of the Association for Information Systems*, 16(1). <https://doi.org/10.17705/1CAIS.01601>
- Otto, B., Bärenfänger, R., & Steinbuß, S. (2015). *Digital Business Engineering: Methodological Foundations and First Experiences from the Field*. 58–76. [https://domino.fov.uni-mb.si/proceedings.nsf/0/52d9349866b3637cc1257e5b0047670b/\\$FILE/2_Otto.pdf](https://domino.fov.uni-mb.si/proceedings.nsf/0/52d9349866b3637cc1257e5b0047670b/$FILE/2_Otto.pdf)
- Özsu, M. T., & Valduriez, P. (2020). Introduction. In M. T. Özsu & P. Valduriez (Eds.), *Principles of Distributed Database Systems* (pp. 1–31). Springer International Publishing. https://doi.org/10.1007/978-3-030-26253-2_1
- Pan, X., Pan, X., Song, M., Ai, B., & Ming, Y. (2020). Blockchain technology and enterprise operational capabilities: An empirical test. *International Journal of Information Management*, 52, 101946. <https://doi.org/10.1016/j.ijinfomgt.2019.05.002>

- Pang, P., Tang, H. F., Lam, J., Cham, J., Hobler, N., Kan, K., Jeong, H., & Lau, R. (2020). *Real Estate Tokenization* [KPMG Insights Report]. KPMG. <https://home.kpmg/cn/en/home/insights/2020/04/real-estate-tokenization.html>
- Paulavicius, R., Grigaitis, S., Igumenov, A., & Filatovas, E. (2019). A Decade of Blockchain: Review of the Current Status, Challenges, and Future Directions. *Informatica*, 30(4), 729–748.
- Pedersen, A., Risius, M., & Beck, R. (2019). A Ten-Step Decision Path to Determine When to Use Blockchain Technologies. *MIS Quarterly Executive*, 18(2). <https://aisel.aisnet.org/misqe/vol18/iss2/3>
- Peppers, K., Tuunanen, T., Rothenberger, M., & Chatterjee, S. (2007). A Design Science Research Methodology for Information Systems Research. *Journal of Management Information Systems*, 24(3), 45–77. <https://doi.org/10.2753/MIS0742-1222240302>
- Perscheid, G., Ostern, N., & Moormann, J. (2020). Determining Platform Governance: Framework for Classifying Governance Types. *ICIS 2020 Proceedings*. https://aisel.aisnet.org/icis2020/governance_is/governance_is/8
- Peters, G., & Panayi, E. (2016). *Understanding Modern Banking Ledgers Through Blockchain Technologies: Future of Transaction Processing and Smart Contracts on the Internet of Money* (pp. 239–278). https://doi.org/10.1007/978-3-319-42448-4_13
- Pilkington, M. (2015). *Blockchain Technology: Principles and Applications*. Social Science Research Network. <https://papers.ssrn.com/abstract=2662660>
- Plazibat, A. (2019). *The Business Potential of Distributed Ledger Technology: Analysis and Recommendations for Action in the Financial Services Sector*. University of St. Gallen.
- Pohl, M., Degenkolbe, R., Staegemann, D., & Turowski, K. (2020). Towards a Blockchain Technology Framework – Literature Review on components in blockchain implementations. *ACIS 2020 Proceedings*. <https://aisel.aisnet.org/acis2020/48>

- Porter, M. (1985). *Competitive Advantage: Creating and Sustaining Superior Performance*. NEW YORK. *The Free Press*.
<https://www.semanticscholar.org/paper/Competitive-Advantage%3A-Creating-and-Sustaining-Porter/f5d6857c5e18f546fed8ba6a5826619cdf55f6c7>
- Provan, K. G., Fish, A., & Sydow, J. (2007). Interorganizational Networks at the Network Level: A review of the empirical literature on whole networks. *Journal of Management*, 479–516.
- Qing, S., Liu, X., & Zheng, H. (2020). An Assessment Framework for Distributed Ledger Technology in Financial Application. *Proceedings of the 2nd ACM International Symposium on Blockchain and Secure Critical Infrastructure*, 161–170.
<https://doi.org/10.1145/3384943.3409432>
- Rauchs, M., Glidden, A., Gordon, B., Pieters, G. C., Recanatini, M., Rostand, F., Vagneur, K., & Zhang, B. Z. (2018). Distributed Ledger Technology Systems: A Conceptual Framework. *SSRN Electronic Journal*. <https://doi.org/10.2139/ssrn.3230013>
- Regner, F., Urbach, N., & Schweizer, A. (2019). NFTs in Practice—Non-Fungible Tokens as Core Component of a Blockchain-based Event Ticketing Application. *ICIS*.
- Reitbauer, S., Kohlmann, F., Eckert, C., Mansfeldt, K., & Alt, R. (2008). Redesigning business networks: Reference process, network and service map. *SAC '08*. <https://doi.org/10.1145/1363686.1363819>
- Riasanow, T., Burckhardt, F., Setzke, D. S., Böhm, M., & Krcmar, H. (2018, August 16). The Generic Blockchain Ecosystem and its Strategic Implications. *AMCIS 2018 Proceedings*.
<https://aisel.aisnet.org/amcis2018/StrategicIT/Presentations/13>
- Richardson, J. (2005). *The Business Model: An Integrative Framework for Strategy Execution*. <https://doi.org/10.2139/ssrn.932998>
- Röck, D., Hofmann, E., & Rogers, D. (2020). Enhancing Transparency in the Supply Chain: An Information Processing Perspective. *Academy of Management Proceedings*, 2020, 21671.
<https://doi.org/10.5465/AMBPP.2020.21671abstract>

- Rogers, E. M. (1962). *Diffusion of innovations*. Free Press of Glencoe.
- Rosemann, M., & vom Brocke, J. (2010). The Six Core Elements of Business Process Management. In J. vom Brocke & M. Rosemann (Eds.), *Handbook on Business Process Management 1: Introduction, Methods, and Information Systems* (pp. 107–122). Springer. https://doi.org/10.1007/978-3-642-00416-2_5
- Ross, O., Jensen, J., & Asheim, T. (2019). Assets under Tokenization: Can Blockchain Technology Improve Post-Trade Processing? *ICIS 2019 Proceedings*. https://aisel.aisnet.org/icis2019/human_computer_interact/human_computer_interact/8
- Rossi, M., Mueller-Bloch, C., Thatcher, J., & Beck, R. (2019). Blockchain Research in Information Systems: Current Trends and an Inclusive Future Research Agenda. *Journal of the Association for Information Systems*, 20(9). <https://doi.org/10.17705/1jais.00571>
- Roth, J., Schär, F., & Schöpfer, A. (2019). The Tokenization of Assets: Using Blockchains for Equity Crowdfunding. *SSRN Electronic Journal*. <https://doi.org/10.2139/ssrn.3443382>
- Rowley, J. (2002). Using case studies in research. *Management Research News*, 25(1), 16–27. <https://doi.org/10.1108/01409170210782990>
- Rowley, J., & Slack, F. (2004). Conducting a literature review. *Management Research News*, 27(6), 31–39. <https://doi.org/10.1108/01409170410784185>
- Rückeshäuser, N. (2017). Typology of Distributed Ledger based Business Models. *ECIS*.
- SAFE. (2021). Principle #9—Decentralize Decision-Making. *Scaled Agile Framework*. <https://www.scaledagileframework.com/decentralize-decision-making/>
- Salipante, P., Notz, W., & Bigelow, J. (1982). A matrix approach to literature reviews. *Research in Organizational Behavior: An Annual Series of Analytical Essays and Critical Reviews*, 4.

- Salmon, J., & Myers, G. (2019). *Blockchain and Associated Legal Issues for Emerging Markets*. International Finance Corporation, Washington, DC. <https://doi.org/10.1596/31202>
- Sandner, P. (2020, May 22). Comparison of Ethereum, Hyperledger Fabric and Corda. *Medium*. <https://philippsandner.medium.com/comparison-of-ethereum-hyperledger-fabric-and-corda-21c1bb9442f6>
- Saraf, C., & Sabadra, S. (2018). Blockchain platforms: A compendium. *2018 IEEE International Conference on Innovative Research and Development (ICIRD)*, 1–6. <https://doi.org/10.1109/ICIRD.2018.8376323>
- Sauer, C., Yetton, P. W., & Alexander, L. (1997). *Steps to the Future: Fresh Thinking on the Management of It-Based Organizational Transformation*. Jossey-Bass Inc., Publishers.
- Savelyev, A. (2018). Some risks of tokenization and blockchainization of private law. *Computer Law & Security Review*, 34(4), 863–869. <https://doi.org/10.1016/j.clsr.2018.05.010>
- Sayre, P. (1927). Elements of a Contract, by Victor Morawetz. *2 Indiana Law Journal* 357 (1927), 2(4). <https://www.repository.law.indiana.edu/ilj/vol2/iss4/9>
- Sazandrishvili, G. (2020). Asset tokenization in plain English. *Journal of Corporate Accounting & Finance*, 31(2), 68–73. <https://doi.org/10.1002/jcaf.22432>
- Schär, F. (2021). *Decentralized Finance: On Blockchain- and Smart Contract-Based Financial Markets* (SSRN Scholarly Paper ID 3843844). Social Science Research Network. <https://doi.org/10.20955/r.103.153-74>
- Schlatt, V., Schweizer, A., Urbach, N., & al, et. (2016). *Blockchain: Grundlagen, Anwendungen und Potenziale*. Fraunhofer FIT.
- Schuff, D., & St. Louis, R. (2001). Centralization vs. Decentralization of application software. *Communications of the ACM*, 44(6), 88–94. <https://doi.org/10.1145/376134.376177>

- Seawright, J., & Gerring, J. (2008). Case Selection Techniques in Case Study Research: A Menu of Qualitative and Quantitative Options. *Political Research Quarterly*, 61(2), 294–308. <https://doi.org/10.1177/1065912907313077>
- Seebacher, S., & Maleshkova, M. (2018). A Model-driven Approach for the Description of Blockchain Business Networks. *HICSS*. <https://doi.org/10.24251/HICSS.2018.442>
- Seebacher, S., Schüritz, R., & Satzger, G. (2021). Towards an understanding of technology fit and appropriation in business networks: Evidence from blockchain implementations. *Information Systems & E-Business Management*, 19(1), 183–204.
- Shah, P., Forester, D., Polk, D., Llp, W., Berberich, M., Raspé, C., & Mueller, H. (2019). Blockchain Technology: Data Privacy Issues and Potential Mitigation Strategies. *Blockchain Technology*, 8.
- Shtybel, U. (2019). A new era of private securities: Application of Blockchain in private capital markets infrastructure. *Journal of Digital Banking*, 4(2), 152–160.
- Siau, K., & Rossi, M. (2011). Evaluation techniques for systems analysis and design modelling methods—a review and comparative analysis. *Inf. Syst. J.*, 21, 249–268. <https://doi.org/10.1111/j.1365-2575.2007.00255.x>
- Simon, H. A. (1969). *The Sciences of the Artificial*. M.I.T. Press.
- Sonnenberg, C., & Vom Brocke, J. (2012). Evaluations in the Science of the Artificial—Reconsidering the Build-Evaluate Pattern in Design Science Research. *DESRIST*. https://doi.org/10.1007/978-3-642-29863-9_28
- Spohrer, J., Maglio, P., Bailey, J., & Gruhl, D. (2007). Steps toward a science of service systems. *Computer*. <https://doi.org/10.1109/MC.2007.33>
- Stähler, P. (2002). *Geschäftsmodelle in der digitalen Ökonomie: Merkmale, Strategien und Auswirkungen*.

- Stefanoski, D., Sahin, O., Banusch, B., Fuchs, S., Andermatt, S., & Quertramp, A. (2020). *Tokenization of Assets Decentralized Finance (DeFi)* (No. 1; p. 65). Ernst & Young. https://assets.ey.com/content/dam/ey-sites/ey-com/en_ch/topics/block-chain/ey-tokenization-of-assets-broschure-final.pdf
- Sternberg, H. S., Hofmann, E., & Roeck, D. (2021). The Struggle is Real: Insights from a Supply Chain Blockchain Case. *Journal of Business Logistics*, 42(1), 71–87. <https://doi.org/10.1111/jbl.12240>
- Strauss, A. L. (1987). *Qualitative Analysis for Social Scientists*. Cambridge University Press. <https://doi.org/10.1017/CBO9780511557842>
- Sunyaev, A., Kannengießner, N., Beck, R., Treiblmaier, H., Lacity, M., Kranz, J., Fridgen, G., Spankowski, U., & Luckow, A. (2021). Token Economy. *Business & Information Systems Engineering*. <https://doi.org/10.1007/s12599-021-00684-1>
- Swan, M. (2015). *Blockchain: Blueprint for a New Economy* (1st ed.). O'Reilly and Associates.
- Sydow, J. (1992). *Strategische Netzwerke: Evolution und Organisation* (1992 edition). Gabler Verlag.
- Szabo, N. (1997). Formalizing and Securing Relationships on Public Networks. *First Monday*. <https://doi.org/10.5210/fm.v2i9.548>
- Tanenbaum, A. S., & Steen, M. van. (2007). *Distributed Systems: Principles and Paradigms*. Pearson Prentice Hall.
- Tapscott, D., & Euchner, J. (2019). Blockchain and the Internet of Value. *Research-Technology Management*, 62(1), 12–19. <https://doi.org/10.1080/08956308.2019.1541711>
- Tasca, P., & Tessone, C. (2018). *Taxonomy of Blockchain Technologies. Principles of Identification and Classification*. <https://doi.org/10.2139/ssrn.2977811>

- Teece, D. J. (2010). Business Models, Business Strategy and Innovation. *Long Range Planning*, 43(2), 172–194. <https://doi.org/10.1016/j.lrp.2009.07.003>
- Teece, D. J. (2018). Business models and dynamic capabilities. *Long Range Planning*, 51(1), 40–49. <https://doi.org/10.1016/j.lrp.2017.06.007>
- Tian, Y., Adriaens, P., Minchin, R. E., Chang, C., Lu, Z., & Qi, C. (2020). *Asset Tokenization: A blockchain Solution to Financing Infrastructure in Emerging Markets and Developing Economies* (SSRN Scholarly Paper ID 3837703). Social Science Research Network. <https://doi.org/10.2139/ssrn.3837703>
- Tilson, D., Lyytinen, K., & Sørensen, C. (2010). *Desperately Seeking the Infrastructure in IS Research: Conceptualization of Digital Convergence As Co-Evolution of Social and Technical Infrastructures*. 1–10. <https://doi.org/10.1109/HICSS.2010.141>
- Timmers, P. (1998). Business Models for Electronic Markets. *Electron. Mark.* <https://doi.org/10.1080/10196789800000016>
- TOGAF. (2021). *The TOGAF® Standard, Version 9.2*. The Open Group. <https://pubs.opengroup.org/architecture/togaf9-doc/arch/>
- Tönnissen, S., & Teuteberg, F. (2020). Analysing the impact of blockchain-technology for operations and supply chain management: An explanatory model drawn from multiple case studies. *International Journal of Information Management*, 52, 101953. <https://doi.org/10.1016/j.ijinfomgt.2019.05.009>
- Tornatzky, L. G., & Fleischer, M. (1990). *The processes of technological innovation*. Lexington Books. <http://archive.org/details/processesoftchn0000torn>
- Torraco, R. J. (2005). Writing Integrative Literature Reviews: Guidelines and Examples. *Human Resource Development Review*, 4(3), 356–367. <https://doi.org/10.1177/1534484305278283>
- Trautman, L. J. (2016). *Is Disruptive Blockchain Technology the Future of Financial Services?* (SSRN Scholarly Paper ID 2786186).

- Social Science Research Network. <https://papers.ssrn.com/abstract=2786186>
- Truong, N., Lee, G. M., Sun, K., Guitton, F., & Guo, Y. (2021). A blockchain-based trust system for decentralised applications: When trustless needs trust. *Future Generation Computer Systems*, 124, 68–79. <https://doi.org/10.1016/j.future.2021.05.025>
- Tushman, M. L., & Nadler, D. (1986). Organizing for Innovation. *California Management Review*, 28(3), 74–92. <https://doi.org/10.2307/41165203>
- Ulrich, W. M., & Newcomb, P. (2010). *Information Systems Transformation: Architecture-Driven Modernization Case Studies*. Morgan Kaufmann Publishers Inc.
- Valdez, S., & Molyneux, P. (2015). *An Introduction to Global Financial Markets*. Macmillan International Higher Education.
- Venkatesh, V. G., Kang, K., Wang, B., Zhong, R. Y., & Zhang, A. (2020). System architecture for blockchain based transparency of supply chain social sustainability. *Robotics & Computer-Integrated Manufacturing*, 63, N.PAG.
- Versteeg, G., & Bouwman, H. (2004). Business architecture: A new paradigm to relate business strategy to ICT. *Information Systems Frontiers*, 8, 91–102. <https://doi.org/10.1007/s10796-006-7973-z>
- Voelpel, S. C., Leibold, M., & Tekie, E. B. (2004). The wheel of business model reinvention: How to reshape your business model to leapfrog competitors. *Journal of Change Management*, 4(3), 259–276. <https://doi.org/10.1080/1469701042000212669>
- Vom Brocke, J. (2003). *Referenzmodellierung: Gestaltung und Verteilung von Konstruktionsprozessen*. Berlin : Logos-Verlag.
- Vom Brocke, J. (2007). Design Principles for Reference Modeling: Re-using Information Models by Means of Aggregation, Specialisation, Instantiation, and Analogy. In P. Fettke & P. Loos, *Reference Modeling for Business Systems Analysis* (pp. 47–76). IGI Global. <https://doi.org/10.4018/978-1-59904-054-7.ch003>

- Vom Brocke, J., Simons, A., Niehaves, B., Riemer, K., Plattfaut, R., & Cleven, A. (2009). Reconstructing the giant: On the importance of rigour in documenting the literature search process. *ECIS*.
- Wang, K., Zhang, Y., & Chang, E. (2020). A Conceptual Model for Blockchain-Based Auditing Information System. *Proceedings of the 2020 2nd International Electronics Communication Conference*, 101–107. <https://doi.org/10.1145/3409934.3409949>
- Wang, S., Ouyang, L., Yuan, Y., Ni, X., Han, X., & Wang, F.-Y. (2019). Blockchain-Enabled Smart Contracts: Architecture, Applications, and Future Trends. *IEEE Transactions on Systems, Man & Cybernetics. Systems*, 49(11), 2266–2277.
- Webster, J., & Watson, R. T. (2002). Analyzing the Past to Prepare for the Future: Writing a Literature Review. *MIS Quarterly*, 2(26).
- Weill, P. (2004). Don't Just Lead, Govern: How Top-Performing Firms Govern IT. *MIS Quarterly Executive*, 3(1). <https://aisel.aisnet.org/misqe/vol3/iss1/3>
- Weill, P., & Vitale, M. (2001). *Place to Space: Migrating to Ebusiness Models*. Harvard Business Press.
- Weingärtner, D. T. (n.d.). *Tokenization of physical assets and the impact of IoT and AI*. 16.
- Wessel, L., Baiyere, A., Ologeanu-Taddei, R., Cha, J., Blegind Jensen, T., TBS Business School, Toulouse, France, Cha, J., University of Westminster, UK, Blegind Jensen, T., & Copenhagen Business School, Denmark. (2021). Unpacking the Difference Between Digital Transformation and IT-Enabled Organizational Transformation. *Journal of the Association for Information Systems*, 22(1), 102–129. <https://doi.org/10.17705/1jais.00655>
- Winter, R. (2007). Relevance and Rigour—What are Acceptable Standards and How are they Influenced? *Wirtschaftsinformatik*, 49(5).
- Winter, R. (2008). Business Engineering: Betriebswirtschaftliche Konstruktionslehre und ihre Anwendung in der Informationslogistik. *Integrierte Informationslogistik*.

- Winter, R., & Fischer, R. (2006). Essential Layers, Artifacts, and Dependencies of Enterprise Architecture. *2006 10th IEEE International Enterprise Distributed Object Computing Conference Workshops (EDOCW'06)*, 30–30. <https://doi.org/10.1109/EDOCW.2006.33>
- Wirtz, B. W. (2020). *Business Model Management: Design - Process - Instruments* (2nd ed. 2020.). 2020.: Cham : Springer International Publishing.
- Wirtz, B. W., Pistoia, A., Ullrich, S., & Göttel, V. (2016). Business Models: Origin, Development and Future Research Perspectives. *Long Range Planning*, 49(1), 36–54. <https://doi.org/10.1016/j.lrp.2015.04.001>
- WKWI. (2003, April 1). Rahmenempfehlung für die Universitätsausbildung in Wirtschaftsinformatik. *Informatik-Spektrum*, 26(2), 108–113.
- Wright, A., & Filippi, P. (2015). *Decentralized Blockchain Technology and the Rise of Lex Cryptographia*. <https://doi.org/10.2139/SSRN.2580664>
- Xie, Z., Hall, J., McCarthy, I. P., Skitmore, M., & Shen, L. (2016). Standardization efforts: The relationship between knowledge dimensions, search processes and innovation outcomes. *Technovation*, 48–49, 69–78. <https://doi.org/10.1016/j.technovation.2015.12.002>
- Xu, X., Weber, I., & Staples, M. (2019). *Architecture for Blockchain Applications*. Springer Nature Switzerland AG.
- Xu, X., Weber, I., Staples, M., Zhu, L., Bosch, J., Bass, L., Pautasso, C., & Rimba, P. (2017). A Taxonomy of Blockchain-Based Systems for Architecture Design. *2017 IEEE International Conference on Software Architecture (ICSA)*, 243–252. <https://doi.org/10.1109/ICSA.2017.33>
- Yee Loong Chong, A., Lim, E. T. K., Xiuping, H., Shuning, Z., & Chee-Wee, T. (2019). Business on Chain: A Comparative Case Study of Five Blockchain-Inspired Business Models. *Journal of the Association for Information Systems*, 20(9), 1308–1337.

- Yin, R. K. (2013). *Case Study Research: Design and Methods* (5th ed.). Sage Publications.
- Yiwei, G., van Engelenburg, S., & Janssen, M. (2021). A Reference Architecture for Blockchain-Based Crowdsourcing Platforms. *Journal of Theoretical & Applied Electronic Commerce Research*, 16(4), 937–958.
- Zachariadis, M., Hileman, G., & Scott, S. V. (2019). Governance and control in distributed ledgers: Understanding the challenges facing blockchain technology in financial services. *Information and Organization*, 29(2), 105–117. <https://doi.org/10.1016/j.infoandorg.2019.03.001>
- Zachman, J. A. (1987). A framework for information systems architecture. *IBM Systems Journal*, 26(3), 276–292. <https://doi.org/10.1147/sj.263.0276>
- Zavolokina, L., Ziolkowski, R., Bauer, I., & Schwabe, G. (2020). Management, Governance, and Value Creation in a Blockchain Consortium. *MIS Quarterly*, 10(1). <https://doi.org/10.17705/2msqe.00022>
- Zhang, A., Zhong, R. Y., Farooque, M., Kang, K., & Venkatesh, V. G. (2020). Blockchain-based life cycle assessment: An implementation framework and system architecture. *Resources, Conservation & Recycling*, 152, N.PAG.
- Zhang, J., Tan, R., Su, C., & Si, W. (2020). Design and application of a personal credit information sharing platform based on consortium blockchain. *Journal of Information Security and Applications*, 55, 102659. <https://doi.org/10.1016/j.jisa.2020.102659>
- Zhang, J., Tian, R., Cao, Y., Yuan, X., Yu, Z., Yan, X., & Zhang, X. (2021). A Hybrid Model for Central Bank Digital Currency Based on Blockchain. *IEEE Access*, 9, 53589–53601. <https://doi.org/10.1109/ACCESS.2021.3071033>
- Zheng, W., Zheng, Z., Chen, X., Dai, K., Li, P., & Chen, R. (2019). Nut-BaaS: A Blockchain-as-a-Service Platform. *IEEE Access*, 7, 134422–134433. <https://doi.org/10.1109/ACCESS.2019.2941905>

- Zhou, T., Li, X., & Zhao, H. (2019). DLattice: A Permission-Less Blockchain Based on DPoS-BA-DAG Consensus for Data Tokenization. *IEEE Access*, 7, 39273–39287. <https://doi.org/10.1109/ACCESS.2019.2906637>
- Zhu, K., Kraemer, K., Xu, S., & Dedrick, J. (2004). Information Technology Payoff in E-Business Environments: An International Perspective on Value Creation of E-Business in the Financial Services Industry. *J. of Management Information Systems*, 21, 17–54. <https://doi.org/10.1080/07421222.2004.11045797>
- Zott, C., Amit, R., & Massa, L. (2011). The Business Model: Recent Developments and Future Research. *Journal of Management*, 37(4), 1019–1042. <https://doi.org/10.1177/0149206311406265>
- Zutshi, A., Grilo, A., & Nodehi, T. (2021). The value proposition of blockchain technologies and its impact on Digital Platforms. *Computers & Industrial Engineering*, 155, N.PAG.
- Zwicky, F. (1969). *Discovery, invention, research through the morphological approach*. Macmillan.

Glossary

Altcoins	The term refers to all cryptocurrencies launched as an alternative to Bitcoin, often with slightly different characteristics and features.
Amazing Blocks	The Amazing Blocks AG is a Liechtenstein-based fintech with around ten employees specializing in digital asset and tokenization services for various industries (Section 4.2.2.1) (https://my.amazingblocks.io).
Asymmetric Cryptography	The term describes public-key encryption methods and digital signature techniques to encrypt and decrypt messages and data in IS between communicating parties. It uses a pair of keys consisting of a secret part (i.e., private key) and a non-secret part (i.e., public key). The public key allows anyone to encrypt data and verify digital signatures, whereas the private key enables its owner to decrypt data, generate digital signatures, or authenticate himself (cf. <i>ISO 21188</i> , 2018).
Atomic Settlement	The term describes the instant exchange and settlement of two assets in which the transfer of one occurs immediately upon the arrival of the other.
B3i	B3i Services AG is a startup founded to explore the potential of using distributed ledger technologies in the re/insurance industry for the benefit of all stakeholders along the value chain (https://b3i.tech).
BaFin	The Federal Financial Supervisory Authority (BaFin) is a German regulatory body with offices in Bonn and Frankfurt that supervises banks, financial service providers, and private insurance companies (https://www.bafin.de).
BEKB	The Berner Kantonalbank AG (BEKB) is one of the largest cantonal banks in Switzerland, with more than 1,200 employees, founded in 1834. Besides its banking offerings, it operates the trading platform OTC-X as a market leader in unlisted securities (https://www.bekb.ch).
Bitcoin	As introduced in Section 2.1.2, Bitcoin is a digital asset and payment system that enables peer-to-peer transactions. It relies on a network of nodes that form a distributed public ledger using a blockchain, which maintains a continuously growing record of transactions decentralized and trustless (cf. Fridgen et al., 2019).
Bitcoin Core Lead Maintainer	The term refers to a group of leading programmers and software engineers who maintain the source code repository of the Bitcoin protocol, also known as Bitcoin core.
Blockchain	A subtype of distributed ledger technology in which confirmed and validated transactions are cryptographically sealed in blocks interlinked in a tamper-resistant append-only chain. Blockchains often represent the basis for cryptocurrencies as they enable a fully public permissionless distributed ledger (cf. <i>ISO 22739</i> , 2020).

Blockdaemon	Blockdaemon is a leading blockchain node infrastructure company to stake, scale, and deploy nodes supporting various blockchains and distributed ledger networks (https://blockdaemon.com).
Byzantine fault tolerance	The term describes the characteristic of a distributed computing system to functioning despite a certain degree of failures in an environment that may be unreliable or malicious (cf. untrustworthy environment) due to unavailable nodes or malicious behavior of nodes (cf. Kannengießer, Lins, Dehling, et al., 2020).
Central Bank Digital Currency	A central bank digital currency is a virtual currency based on encryption algorithms issued and regulated by central banks (J. Zhang et al., 2021).
Chainlink	Chainlink is an Ethereum based technology and decentralized blockchain project that enables smart contracts on Ethereum to securely connect to external off-chain data sources, APIs, and payment systems (https://chain.link/).
Coinbase	Coinbase is a US-based public listed company that operates a trading platform for cryptocurrencies such as Bitcoin, Ethereum, Litecoin, and many more to be traded and further exchanged for fiat currencies (https://www.coinbase.com).
Consensus Mechanism	The consensus mechanism (also known as consensus algorithm) defines how system participants (i.e., nodes) agree to synchronize transactional data and maintain consistency without relying on a central authority. The mechanism is essential to the functioning of any blockchain or distributed ledger. In practice, there are various mechanisms to achieve this. The most popular consensus mechanisms are proof of work and proof of stake (cf. <i>ISO 22739</i> , 2020).
ConsenSys	ConsenSys is a blockchain software technology company founded in 2014 as a global community of developers, businessmen, programmers, journalists, and lawyers to promote blockchain infrastructure, peer-to-peer applications, and decentralized software services based on Ethereum (https://consensys.net).
Crypto Kitties	Crypto Kitties is an Ethereum-based online game that allows users to trade, collect, and breed virtual cats as unique, indivisible, irreplaceable, and verifiable representations on the BC using Ethereum's non-fungible tokens standard ERC-721 (https://www.cryptokitties.co).
Cryptocurrencies	Cryptocurrencies (also known as cryptoassets, (crypto)coins, or (crypto) tokens) are digital assets that operate on a distributed ledger and use cryptographic techniques to secure transactions without relying on a trusted third party (cf. <i>ISO 22739</i> , 2020).
Cryptographic Keys	In cryptography, a key is information that parameterizes a cryptographic algorithm to encrypt or decrypt data, often using mathematical methods to be found in symmetric or asymmetric cryptography.

Daura	Daura is a Swiss fintech founded in 2018 that operates a tokenization platform and provides services to digitize shares of Swiss SMEs, where processes (e.g., capital increases) are facilitated and conducted more efficiently.
Decentralized Applications	The term describes a software application that builds upon a distributed digital platform (e.g., a distributed ledger) and does not implement a central authority to manage computing nodes operating the digital platform.
Decentralized Autonomous Organization	A decentralized autonomous organization is a more complex form of a DApp. However, it is not a standalone application but a predefined program acting as an entity with no central leadership. It is based on distributed ledger technology and characterized by autonomous actions using smart contracts.
Decentralized Finance	Decentralized Finance is based on blockchain protocols that replicate existing financial services using tokens (e.g., lending and borrowing, creating and trading of derivatives) in a more open, interoperable, and transparent way. These applications often relate to an incentivized provision of collateral and liquidity using cryptocurrencies (cf. yield farming) of users on decentralized markets, which do not rely on intermediaries and centralized institutions (cf. Schär, 2021).
Decentralized information systems	Decentralized information systems are distributed IT systems that usually comprise a network of separate computing devices (i.e., nodes) that interact without mediation (e.g., a server that forwards requests). It functions as a unified system, where the nodes can take different roles with individual tasks specified in one shared protocol. The roles comprise, for example, the forwarding of network data or proposing new data to be stored by other nodes in a distributed database. One of the most popular means to enable a decentralized IS is distributed ledger technology (cf. Heines, Kannengießer, et al., 2021).
DeFi Community	The term typically refers to the open-source community of users, programmers, and other individuals that utilize and further develop DeFi applications, services, and products.
Digital Assets	The term describes assets that exist only in digital form or represent a digitized representation of an asset (e.g., virtual asset), often used as an umbrella term for cryptoassets.
Distributed Ledger Technology	Distributed Ledger Technology enables the operation of a highly available, append-only distributed database for transactions (i.e., a distributed ledger) with distributed storage and computing devices (i.e., nodes) in an untrustworthy environment with arbitrary occurrences of (temporarily) unreachable nodes or fraudulent actions (e.g., double-spending) (cf. Kannengießer, Lins, Dehling, et al., 2020) (Section 2.1).

Double Spending	Double spending is often associated with transferring crypto assets on DLT platforms when a token or crypto asset is mistakenly transferred more than once (cf. <i>ISO 22739</i> , 2020).
ERC-20	ERC-20 is a token contract standard of the Ethereum blockchain that allows the implementation of a standard API for tokens within smart contracts. The standard provides basic functionality to transfer tokens and enables tokens to be approved so they can be spent by another party (https://eips.ethereum.org).
ERC-721	ERC-721 is an Ethereum token contract standard that enables the implementation of a standard API for non-fungible tokens (NFT) within smart contracts. It provides basic functionality for tracking and transferring NFTs that represent ownership of distinguishable and distributed digital assets (https://eips.ethereum.org).
Ether	Ether (abbreviated with ETH) is the native cryptocurrency of Ethereum as an internal unit of payment for transaction processing on its blockchain, which is handled by participating computers.
Ethereum	Ethereum is an open-source platform that provides a blockchain-based virtual machine using the Solidity programming language for developing distributed applications. It focuses mainly on smart contract deployment and execution, built and operated on top of its public permissionless infrastructure (https://ethereum.org).
Fine Wine Capital	Fine Wine Capital AG is a Swiss-based wine trading company and is part of a larger tokenization solution of the financial technology provider Sygnum AG. The company was involved in launching an asset token representing a selection of premium wines for investment and trading purposes, where it physically stored the token-backed premium wines (https://finewinecapital.com).
FINMA	The Swiss Financial Market Supervisory Authority (FINMA) is a regulatory body supervising the Swiss financial market to maintain its functioning and controls all areas of finance, in particular banks, insurance companies, stock exchanges, brokers, and auditing companies (www.finma.ch).
Hard Fork	A hard fork is a blockchain protocol change requiring all network nodes to update their software to the latest version to create new ledger records or blocks in the network.
Hash	A hash is a string value of bits which is the output of a cryptographic hash function that turns an arbitrary long row of ciphers into a unique signature of 128 or 256 bits (~ 40 or 80 decimal ciphers) (cf. <i>ISO 22739</i> , 2020).
Hyperledger	Hyperledger is an open-source platform initiated by the Linux Foundation and enables the collaborative development of DLT-based industry applications providing numerous frameworks (e.g., Hyperledger Fabric, Sawtooth, or Indy). Also known as the Hyperledger Consortium

	Blockchain, a focus lies on private permissioned ledgers for commercial use (https://www.hyperledger.org).
InCore	InCore Bank AG is a Swiss business-to-business transaction bank offering transaction banking and outsourcing services to banks, securities firms, institutional investors, and fintech companies.
Initial Coin Offering	Initial Coin Offerings are a new fundraising method for a group of developers or a company that seeks public investments for a blockchain project or business in return using cryptoassets created and issued on a distributed ledger (Roth et al., 2019).
Meta-Data	The term describes structured data that contains information about characteristics of other data. For example, the data represented by meta-data is often a more extensive collection of data sets such as documents, books, databases, or other files.
MetaMask	MetaMask is a crypto wallet that supports all types of Ethereum-based tokens and further allows a seamless connection to smart contracts and decentralized applications (https://metamask.io).
Micropayment	A payment transfer based on very low values from one party to another requires frictionless transactions with almost no transaction fees to be profitable.
Miner	A miner is a node in a distributed ledger network that specializes and engages in mining, typically an individual or organization.
Mining	Mining is the process of creating and validating blocks in a blockchain network to ensure the consistency of transactions using computational resources. With this, electricity is typically required to join a probabilistic, computer-based competition in which participants are incentivized via an algorithmic distribution of token rewards (cf. Alsindi & Lotti, 2021; Xu et al., 2019).
Multi-signature transaction	A transaction requires the signatures of multiple parties to provide a higher degree of security and validation before the transaction is broadcast onto the blockchain.
Native Token	Native tokens exist on-chain and are implemented as part of particular DLT-infrastructure where they derive their value in and of themselves. Many cryptocurrencies, such as Bitcoin, are native to their underlying blockchain protocol to be transferred between users. On the one hand, Bitcoins are required in terms of transactions fees. On the other hand, a user can receive rewards for Bitcoins via successful mining (cf. OECD, 2020).
Node	The distributed ledger relies on separate computing devices, also known as nodes, that communicate with each other and operate in a distributed, decentralized fashion. For example, a node can cover some or all of the functional components of the system ranging from storing,

	receiving, or sending transactions to even running an instance of a virtual machine (cf. <i>ISO 22739</i> , 2020).
Non-Fungible Token	Often used to create digital scarcity, non-fungible tokens are unique digital assets that cannot be exchanged one for another. They are distinguishable by individual specification and can represent anything from a piece of land to collectibles.
Non-Native Token	A non-native token is built upon the protocol layer and on top of an existing distributed ledger. It is deployed as a smart contract, often utilizing a predefined token standard (e.g., ERC-20) (cf. Ketz & Sandner, 2019).
Off-Chain Data	Data related to a DLT but stored outside the system is referred to as off-chain data. For example, raw reference data is typically stored off-chain (cf. content addressing) to improve storage capabilities, confidentiality, and performance within a shared infrastructure (cf. Xu et al., 2017).
On-Chain Data	Data related to a DLT stored within the system is called on-chain data. For example, meta-data of larger data sets are typically stored on-chain (e.g., timestamps, hashes) to improve the performance within the shared infrastructure (cf. Xu et al., 2017).
Paxos	Paxos is a US-based financial institution and technology company specializing in blockchain. The company's product offerings include a cryptocurrency brokerage service, asset tokenization services, and settlement services (https://paxos.com).
Permissioned	The term is typically associated with a closed system that requires permission to conduct a particular activity (<i>ISO 22739</i> , 2020).
Permissionless	The term is typically related to an open system not requiring authorization to perform any particular activity (<i>ISO 22739</i> , 2020).
Private DLT	The term describes a distributed ledger network that is accessible for use only to a limited group of users (<i>ISO 22739</i> , 2020).
Private Key	An encryption key is uniquely linked to an asymmetric key pair of an entity that is kept secret and should only be used by that entity (<i>ISO 22739</i> , 2020).
Proof of Stake	This particular consensus mechanism supports the network's operations by locking cryptocurrencies and being rewarded for contributing to the consensus proportionally to the number of coins staked (Alsindi & Lotti, 2021, p. 5).
Proof of Work	This specific consensus mechanism requires computational resources to let participants (i.e., Miner) solve a complex mathematical problem and add transactions. In this sense, the miners must compute many hashes until a winning hash is produced. Finding a correct solution requires much energy, but the mechanism is easily verifiable.
Pseudonymity	Each entity within the network requires cryptographic keys to access an account on the distributed ledger. Thus, for a person holding the key

	pair, the system is pseudonymous since any action can only be traced back to the specific address of the public key but not to the holder itself.
Public DLT	A network in which anyone can participate by reading data, submitting transactions, and participating in the validation process (<i>ISO 22739, 2020</i>).
Public Key	An encryption key is uniquely linked to an asymmetric key pair of an entity that is made public (<i>ISO 22739, 2020</i>).
Public Key Infrastructure	Public key infrastructure is a system that manages digital certificates for various purposes, typically applying cryptography. For example, certificates with public key infrastructure are used to secure communication, where messages in a network are digitally signed and encrypted (cf. <i>ISO 21188, 2018</i>).
R3 Corda	The platform was founded in 2014 as a technology consortium for banks to enable the operation of distributed ledgers for various application areas in the financial services sector. Specifically used to record and process financial agreements, its infrastructure is designed for business transactions and can provide a so-called cryptographic proof of settlement (https://www.r3.com).
Security Token Offering	A security token offering describes a public sale of assets, rights, or debt relationships using tokens. They are conducted in a more regulated environment, meeting higher issuance, storage, and trade standards than initial coin offerings.
Smart Contracts	Smart contracts are software programs that deploy business logic formalized in computer code for reliable enforcement of business agreements between participants, such as individuals, firms, or machines (Kannengiesser et al., 2021).
Stable Coins	Stable coins are usually associated with a specific subset of cryptocurrencies. Their price is controlled by active or automatic mechanisms to prevent price fluctuations and can be pegged to a national currency, a basket of currencies, or other commodities and assets.
Stellar Blockchain	The Stellar blockchain is classified as an open-source public permissionless distributed ledger. Compared to Ethereum, the Stellar consensus protocol enables higher transaction throughput, low-cost fees, and transaction finality (https://www.stellar.org).
TokenX	The fintech TokenX is based in Switzerland and was founded in 2021 as a spin-off of Alpine Tech, which pioneered early in crypto mining. As a growing startup, the company employs up to ten people and has developed a technology platform for regulated financial institutions to trade security tokens seamlessly on internal marketplaces (https://www.tokenx.com).
Token	A token is a representation of an underlying asset or a collection of entitlements (<i>ISO 22739, 2020</i>).

Token Contract	A more specified smart contract that uses the programmable logic of a token transfer is also called a token contract. For example, one standard refers to the ERC-20 or ERC-721 token contract for a token issuance on the Ethereum blockchain.
Token Economy	The economic and social activities facilitated by a next-generation internet using tokens (i.e., Web3) are commonly referred to as a token economy.
Tokenization	Tokenization refers to the process of creating a unique singular identifier on a distributed ledger in the form of a token that may digitally represent anything from valuable objects (e.g., artwork) or contractual rights (e.g., ownership right) (Distefano et al., 2020).
Uniswap	Uniswap is a decentralized cryptocurrency exchange that enables automated transactions between cryptocurrencies and tokens on the Ethereum blockchain through smart contracts. The decentralized exchange is based on Defi protocols and operates without the mediation of a third party (https://uniswap.org).
Wallet	A wallet is an application used to generate, manage, store or use private and public keys. Like a digital purse, it is typically applied to make transfers of cryptocurrencies or check balances. Contrary to popular belief, a wallet does not contain any assets but the keys to interact with the distributed ledger (cf. <i>ISO 22739</i> , 2020).
Web3	Web3 is a concept for a new generation of the World Wide Web based on blockchain and distributed ledger technology, incorporating concepts such as decentralization and token-based economy.

Appendices

Appendix A: DLT Basics

A.1: Description of DLT Types

A.2: Exemplary Token Contract Code

Appendix B: Artifact Design Process Overview

B.1: DSR Process Overview

B.2: Excerpt of the Meta-Requirements Questionnaire

Appendix C: Focus Group Meetings

C.1: CC Ecosystems Workshops

C.2: CC Ecosystems Working Groups

Appendix D: Asset Tokenization Framework

D.1: Initial Concept Matrix of the Assessment Framework

D.2: Excerpt of the Assessment Framework Interview Guide

D.3: Overview of Archetypes and Sub-criteria

Appendix E: Conceptual Model

E.1: Initial Concept Matrix of the Conceptual Model

E.2: Overview of Case Study Meetings

E.3: Excerpt of the Case Study Interview Guide

E.4: Model Elements and their Relationships

Appendix F: Organizational Principles

F.1: Excerpt of the Interview Guide for Organizational Change

F.2: Overview of Challenges and Descriptions

F.3: BIAN Service Landscape

F.4: Screenshot of the Website for Artifact Evaluation

Appendix A: DLT Basics

Appendix A.1: Description of DLT Types

Bitcoin: As introduced in Section 2.1.2, the basic concept of BC and DLT originated from the Bitcoin protocol. It follows public and permissionless design, where anyone can participate in consensus and transaction validation without authorization. The system is characterized by a high degree of decentralization due to its number of distributed nodes. Due to this design, security-related requirements for the system (e.g., pseudonymity) cannot be fully met according to known data protection and confidentiality standards. As a first-generation BC, Bitcoin applies a native cryptocurrency of the same name to be created and transferred between network participants. The resource extensive PoW algorithm with Bitcoin rewards represents the underlying consensus and incentive mechanism (cf. Fridgen et al., 2019).

Ethereum: The Ethereum BC is an open-source platform that provides a BC-based virtual machine using the Solidity programming language for developing distributed applications. It focuses mainly on smart contract deployment and execution, built and operated on top of its public permissionless infrastructure. Therefore, every node in the systems runs a virtual machine for distributed program execution, while the Ethereum infrastructure independently verifies relevant inputs and outputs for execution. As a result, DApps are enabled, not governed by any individual or central entity (e.g., Crypto Kitties). However, it also provides the *Enterprise Ethereum* functionality and adds an enterprise-focused extension to the public network, allowing private transactions. The main network of Ethereum uses the proof of work consensus mechanism but is pursuing a switch from PoW to PoS. In private networks, proof of authority or alternative mechanisms can be implemented. For the incentivization of the network, it uses the native currency Ether (cf. Saraf & Sabadra, 2018).

Hyperledger: The DLT is an open-source platform initiated by the Linux Foundation and enables the collaborative development of DLT-based industry applications. Numerous frameworks and protocols exist,

including Hyperledger Fabric, Sawtooth, or Indy, to support different use cases in various industries (e.g., finance, supply chain management, healthcare). Also known as the *Hyperledger Consortium Blockchain*, a focus lies on private permissioned ledgers for commercial use. Therefore, each participant is a registered member authorized through membership and a service provider. For the transactions, a mechanism through channels is applied, which guarantees that only members of the channel can access transactional data. Moreover, the consensus mechanism is adaptable according to the use case requirements. In addition, chaincode is used to deploy smart contracts (cf. Sandner, 2020; Saraf & Sabadra, 2018).

R3 Corda: The platform was founded in 2014 as a technology consortium for banks to enable the operation of distributed ledgers for various application areas in the financial services sector. Specifically used to record and process financial agreements, its infrastructure is designed for business transactions and can provide a so-called cryptographic proof of settlement (e.g., payment transactions). In addition, the involved parties have to be authorized, leading to a private permissioned system. For example, the states of objects might represent any digital document as agreements to be exchanged between parties. The state object can be accessed only by predefined and privileged users. As a result, various workflows can be integrated to operate without a central authority. The business logic for these workflows is implemented using *smart contract code*, where different consensus algorithms are supported. Today it extends its platform for other use cases to improve interoperability between companies across industries (cf. Sandner, 2020; Saraf & Sabadra, 2018).

Appendix A.2: Exemplary Token Contract Code

```
1  pragma solidity ^0.4.4;
2
3  import "./Token.sol";
4
5  contract StandardToken is Token {
6
7      function transfer(address _to, uint256 _value) returns (bool success) {
8          if (balances[msg.sender] >= _value && _value > 0) {
9              balances[msg.sender] -= _value;
10             balances[_to] += _value;
11             Transfer(msg.sender, _to, _value);
12             return true;
13         } else { return false; }
14     }
15
16     function transferFrom(address _from, address _to, uint256 _value) returns (bool success) {
17         if (balances[_from] >= _value && allowed[_from][msg.sender] >= _value && _value > 0) {
18             balances[_to] += _value;
19             balances[_from] -= _value;
20             allowed[_from][msg.sender] -= _value;
21             Transfer(_from, _to, _value);
22             return true;
23         } else { return false; }
24     }
25
26     function balanceOf(address _owner) constant returns (uint256 balance) {
27         return balances[_owner];
28     }
29
30     function approve(address _spender, uint256 _value) returns (bool success) {
31         allowed[msg.sender][_spender] = _value;
32         Approval(msg.sender, _spender, _value);
33         return true;
34     }
35
36     function allowance(address _owner, address _spender) constant returns (uint256 remaining) {
37         return allowed[_owner][_spender];
38     }
39
40     mapping (address => uint256) balances;
41     mapping (address => mapping (address => uint256)) allowed;
42     uint256 public totalSupply;
43 }
```

Appendix B: Artifact Design Process Overview

Appendix B.1: DSR Process Overview

Outcome	Analysis	Design	Evaluation	Diffusion
Artifact I	1xLiterature Review (<i>Blockchain* OR Distributed Ledger*</i>) AND (<i>Token*</i>) AND (<i>Tokenization OR Tokenisation</i>) 3xFocus Group: CC8 WS1, CC8 WS2, WGI	2xFocus Group: CC8 WS5, WGV 1xExpert Interviews (<i>n</i> =22)	1xFocus Group: CC9 WS1 1xExpert Interviews (<i>n</i> =3)	Publication, Workshops, Lectures
Artifact II	1xLiterature Review (<i>Platform* OR Model* OR Framework* OR Architecture*</i>) AND (<i>Blockchain* OR Distributed Ledger*</i>) 2xFocus Group: CC8 WS2, WGI	4xFocus Group: CC8 WS4, CC8 WS6, WGI/III, WGI/IV, 1xMultiple Case Studies (<i>n</i> =6)	1xSingle Case Study (<i>n</i> =2) 1xInterview Questionnaire (<i>n</i> =12)	Workshops, Lectures
Artifacts III	1xLiterature Review (<i>implication* OR challenge* OR corporate culture* OR business process*</i>) AND (<i>blockchain* OR distributed ledger*</i>) 2xFocus Group: CC8 WS2, WGI	1xFocus Group: WGI 1xExpert Interviews (<i>n</i> =13)	1xFocus Group: CC9 WS2 1xOnline Questionnaire (<i>n</i> =10)	Publication, Workshops, Lectures

Appendix B.2: Excerpt of the Meta-Requirements Questionnaire (1/2)

Gruppenarbeit

Service Design im Kontext

Blockchain- und DLT

Fragebogen zum Status Quo und Validierung von
Thesen CC 8 - Workshop 2

Bad Horn, 22.05.2019

Hintergrund

- Unter Berücksichtigung der Fähigkeiten und Eigenschaften der Technologie ist es das Ziel des Fachvortrags eine geeignete Struktur einzuführen, welche erste Erkenntnisse für die modellorientierte und methodengetriebene Gestaltung von Blockchain- und DLT basierten Services liefert
- Da der Einsatzzweck und der Nutzen der Technologie immer noch sehr unscharf ist, soll im Rahmen eines Fragebogens der aktuelle Entwicklungsstand, die Herausforderungen und die Schwerpunkte mithilfe eurer Praxiserfahrung identifiziert, geschärft und vertieft werden
- Die Gruppenarbeit gliedert sich in einen Teil «Fragebogen» und einen Teil «Thesen»

Dauer	25 Min.	20 Min.	10 Min.
Vorgehen	Individuelle Bearbeitung des Fragebogens im Teil 1 sowie der Thesen in Teil 2	Gruppendiskussion und Validierung der ausgewählten Thesen in Teil 2	Konsolidierung der Ergebnisse im Plenum

Aufgabenstellung:

1. Bitte bearbeitet den Fragebogen zur vorgestellten Thematik «Blockchain- und DLT basierte Services» in Teil 1 sowie die Thesen zur Validierung in Teil 2 (**25 Min**)
2. Konzentriert euch anschliessend auf Teil 2 und diskutiert gemeinsam die ausgewählten Thesen im Kontext Blockchain und DLT basierter Services (**20 Min**)
3. Das gesammelte Feedback in der Gruppenarbeit wird von den Moderatoren im Plenum abschliessend erläutert (**10 Min**)

Danke euch!

Appendix B.2: Excerpt of the Meta-Requirements Questionnaire (2/2)

Teil 1: Fragebogen

4.2: Anforderungen an die Systemunterstützung mit Blockchain und DLT

Wie sehr stimmst du folgenden Aussagen zum Einsatz von BCT und DLT in der Finanzindustrie zu?

	Stimme gar nicht zu	Stimmt nicht zu	Stimme mittel zu	Stimme zu	Stimme voll zu	Keine Angabe
Die Anforderungen an die technische IT-Sicherheit sind ein Hemmnis	☐	☐	☐	☐	☐	☐
Die datenschutzrechtlichen Bestimmungen sind ein Hemmnis	☐	☐	☐	☐	☐	☐
Aufgrund fehlender Standards sind Lösungen derzeit zu wenig ausgereift	☐	☐	☐	☐	☐	☐
Die Auswahl einer geeigneten BCT und DLT Technologie zur Umsetzung ist schwierig	☐	☐	☐	☐	☐	☐
Die Integration in bestehende Systeme ist eine Herausforderung	☐	☐	☐	☐	☐	☐
Das Security-Management für private Keys und Passwörter ist eine Herausforderung	☐	☐	☐	☐	☐	☐
Vorliegende Daten sind aufgrund ihrer Qualität nicht geeignet (Dateninkonsistenz)	☐	☐	☐	☐	☐	☐
Unklarer Entwicklungs- horizont und nicht abschätzbare Lebensdauer der BCT und DLT	☐	☐	☐	☐	☐	☐

Wo siehst du aus technischer Sicht die grösste Herausforderung?

(Gerne auf Rückseite fortfahren) →

Appendix C: Focus Group Meetings

Appendix C.1: CC Ecosystems Workshops

Workshops	Venue	Duration	Date	Description
CC8 WS1	Filzbach (CH)	60 Min	15.02.2019	Identification of potentials for tokenized assets and requirements for tokenization
CC8 WS2	Bad Horn (CH)	60 Min	22.05.2019	Discussion on current developments and identification of challenges and key themes within the research area of BC and DLT
CC8 WS3	Heidelberg (D)	75 Min	27.09.2019	Business analysis for a DLT prototype
CC8 WS4	Wildhaus (CH)	60 Min	14.02.2020	Validation of the conceptual framework (first iteration) and prototype finalization
CC8 WS5	Romanshorn (CH)	60 Min	22.06.2020	Requirements for token-based business models in the financial industry
CC8 WS6	Säntis (CH)	45 Min	04.09.2020	Requirements for DLT based use cases in the financial industry
CC9 WS1	Virtual	60 Min	11.02.2021	Validation of tokenization archetypes
CC9 WS2	Virtual	60 Min	19.05.2021	Discussion of DLT-challenges, their impact on business functions, and potential solutions

Company	Type	Job Position	Workshops							
			CC8 WS1	CC8 WS2	CC8 WS3	CC8 WS4	CC8 WS5	CC8 WS6	CC9 WS1	CC9 WS2
Atruvia (Fiducia)	IT Service Provider	Manager Innovation		X						
		Sales Management	X		X	X		X	X	
		Sales Manager						X		X
Julius Baer	Bank	Division Manager			X					
		Executive Director	X	X						
		Executive Director	X			X				
		Global Head Products	X	X	X					
Bank-Verlag	IT Service Provider	Business Developer	X		X				X	X
		Head of Strategy	X							
BEKB	Bank	Head of Digital Transformation	X	X		X				
		Head of Innovation						X	X	X
		Head of Product Management	X	X		X	X			
		Manager Innovation							X	X

Company	Type	Job Position	Workshops							
			CC8 WS1	CC8 WS2	CC8 WS3	CC8 WS4	CC8 WS5	CC8 WS6	CC9 WS1	CC9 WS2
Commerzbank	Bank	Business Developer					X	X		
		Head of API Banking							X	
		Manager Digital Transformation						X	X	
		Product Owner							X	
DZ BANK	Bank	Sales Manager	X		X	X		X	X	
DXC Technology	IT Service Provider	Chief Industry Architect	X							
		Enterprise Architect	X	X					X	
		Product Owner				X	X	X		
Esprit	IT Service Provider	Lead Business Integration							X	X
Finnova	IT Service Provider	Head Ecosystems		X					X	
		Head of Transformation				X				
		Product Manager	X	X				X		X
GKB	Bank	Manager Innovation				X		X		
Hypothekbank Lenzburg	Bank	Business Analyst	X							
		Chief Product Officer	X	X		X				
		Enterprise Architect			X	X	X	X		
Hypo Vorarlberg	Bank	Digitalisation Manager					X			
		Director IT	X	X	X	X		X	X	
		Head of Digitalization				X	X	X	X	X
		IT Manager	X	X						
LBBW	Bank	Business Developer			X					
		Digitalisation Manager		X						
		Manager Innovation						X		
		Lead Innovation Manager	X	X	X	X		X	X	
Postfinance AG	Bank	IT Architect							X	
		Product Manager	X	X						
		Senior Strategy Manager		X						
		Senior Strategy Manager	X	X						
Raiffeisen	Bank	Head Marketing		X						
		Project Manager	X							
SIX Group	Financial Infrastructure Provider	Business Developer	X							
		Business Developer	X							
		Business Developer	X	X	X	X			X	X
		Head of Product	X							
		Innovation Manager						X		

Company	Type	Job Position	Workshops							
			CC8 WS1	CC8 WS2	CC8 WS3	CC8 WS4	CC8 WS5	CC8 WS6	CC9 WS1	CC9 WS2
Swisscom	IT Service Provider	Head of Banking Transformation	X	X			X	X	X	X
		Product Manager							X	
		Senior Banking Architect	X	X		X	X		X	X
VP Bank	Bank	Business Developer							X	
VZ Vermögenszentrum	Financial Services	Senior Business Developer	X			X				
		Strategy Manager	X	X						

Appendix C.2: CC Ecosystems Working Groups

Working Groups	Format	Duration	Date	Description
WGI	Telephone call	60 Min	26.04 - 10.05.2019	Kick-off research topics and discussion of the problem domain
WGII	Conference call	60 Min	12.12.2019	Finalization of a BC-based mortgage process architecture, solution design of the classificatory framework, and refinement of WS2 survey
WGIII	Online Conference	60 Min	05.02.2020	Discussion on BC classification, tokenization framework, and prototype
WGIV	Online Conference	60 Min	15.04 - 16.04.2020	Discussion on reference model (second iteration), prototype, and BC business models
WGV	Online Conference	60 Min	25.08 - 31.08.2020	Design of asset tokenization archetypes and finalization of DLT prototype for process management in the mortgage business
WGI	Online Conference	60 Min	01.02.2021	Discussion of DLT-challenges, their impact on business functions, and potential solutions

Company	Type	Job Position	Working Groups					
			WGI	WGII	WGIII	WGIV	WGV	WGI
Atruvia (Fiducia)	IT Service Provider	Sales Manager		X	X	X	X	
DXC Technology	IT Service Provider	Chief Industry Architect	X	X		X		X
Hypo Vorarlberg	Bank	IT Manager		X			X	X
Hypothekbank Lenzburg	Bank	Enterprise Architect				X	X	X
		Project Manager				X		
Julius Baer	Bank	Division Manager		X	X			
		Global Head Products	X	X	X	X		
SIX Group	Financial Infr. Provider	Business Developer	X	X	X	X	X	X
VZ Vermögenszentrum	Financial Services	Senior Business Developer	X	X	X			

Appendix D: Asset Tokenization Framework

Appendix D.1: Initial Concept Matrix of the Assessment Framework

Reference	Token properties	Dem. & facilitated access	Fractional ownership	Increased liquidity	Disintermediation	Increased transparency	Process optimization	Digital scarcity	Legacy structures	Data privacy	Technical	Regulatory & legal	Governance	Oracle problem
(Ankenbrand et al. 2020)	X													
(Babich & Hilary 2020)		X			X		X							
(Ballandies et al. 2020)	X													
(Barnes 2020)				X		X	X							
(Blémus & Guegan 2019)		X		X	X	X								
(Chen 2018)		X		X				X				X		
(Euler 2018)	X													
(FINMA 2018)	X													
(Freni et al. 2020)	X													
(Guadamuz 2019)													X	X
(Hartung et al. 2019)				X	X		X		X		X	X		
(Harwood-Jones 2019)		X	X	X			X				X		X	
(Hrga et al. 2020)					X	X	X							
(IWA 2020)	X													
(Kaur & Oza 2020)			X			X								
(Ketzer & Sandner 2019)	X													
(Khan et al. 2020)		X	X	X	X	X	X			X	X	X		
(Kim 2020)			X	X		X	X							
(Li et al. 2019)						X	X							
(Lotti 2019)		X	X		X		X	X			X	X		
(Macedo 2019)	X	X			X		X	X						
(Marshall et al. 2018)	X													
(Meijer 2020)							X	X						
(Mougayar 2018)	X													
(Mueller et al. 2018)	X													
(Narayan & Tidström 2020)		X				X	X						X	
(Oliveira et al. 2018)	X													
(Regner et al. 2019)				X			X	X			X	X		
(Ross & Jensen 2019)					X	X	X							
(Roth et al. 2019)		X	X				X				X	X		
(Savelyev 2018)						X	X							
(Sazandrishvili 2020)		X	X	X	X	X	X				X	X		
(Shtybel 2019)		X	X	X		X	X			X	X			
(Weingärtner 2019)			X	X			X							

Appendix D.2: Assessment Framework Interview Guide (1/2)

A conceptual framework for understanding the business potential of tokenization

Interview Guide

Dear Participant

Thank you for your interest and time to participate in our study on tokenization. The interview will take approximately 45 min of your time and is divided into four parts: Demographics, Potentials and Challenges, Evaluation of a Framework, and Concluding Remarks. This is an exploratory study and there are no wrong answers. The content will be kept confidential, and the findings will be processed anonymously.

Background

Distributed Ledger Technology (DLT) allows transactions to be mapped and processed in a new way in distributed database systems. In addition to various application scenarios (e.g., cryptocurrency settlement), the concept of tokenization has emerged in the context with DLTs recently. Accordingly, it describes the creation of a token in the form of an "identifier" on a "distributed ledger", which can represent, for example, a (complex) bundle of rights with "smart contracts". Once an underlying legal relationship is established and a specific bearer is assigned to this right, the token can become the subject of an instantiation in the physical world. In doing so, it is possible to represent almost anything from assets, digital goods to other valuable resources.

Where the socio-technical concept of tokenization based on DLTs is said to lead to greater efficiency, collaboration or democracy, it is necessary to generate further insights on practical benefits and implications on existing structures, processes or even business models.

The goal is to develop a framework for evaluation of different tokenization scenarios to help companies to individually assess use cases. In the context of a FinTech analysis, archetypal patterns are further identified based on the framework, which can then serve as a starting point for the development of practicable applications and future research.

I. Demographics

Position/ Job Titel

Field of activity

Industry / Company

Number of employees

How long have you been involved with DLT?

What are your experiences with DLT?

Prior Knowledge of Tokenization

How would you rate your knowledge of distributed ledger technology (DLT) or tokenization?

No

knowledge

☐

Limited
knowledge

☐

Medium
knowledge

☐

High
knowledge

☐

Very high
knowledge

☐


Appendix D.2: Assessment Framework Interview Guide (2/2)

Interview Guide

II. Evaluation of the overall Framework

- I. What are use cases, initiatives, or projects associated currently operating or under discussion in your company or consortium?

Potentials and challenges in the context of “Tokenization”

- 1) What do you understand by the term tokenization?
- 2) Where do you see possible value propositions, potentials and drivers for tokenization solutions (not only related to "bankable assets" but also beyond the financial industry)?
 - a) Fractional Ownership
 - b) Digital Scarcity
 - c) ...
- 3) What do you see as challenges and barriers for applying tokenization?
 - a) Legacy Systems
 - b) Platform Governance
 - c) ...
- 4) What new business models and services do they think can emerge?

III. Evaluation of a framework for the assessment of use cases

- 1) What are use cases in the context of tokenization that are currently being discussed in your company? How do you evaluate possible scenarios?
- 2) Which features or characteristics do you think are relevant for characterizing use cases?
 - (See example framework and criteria in the appendix)
- 3) What is suitable for tokenization, and why? What additional benefit can be generated in the specific case?
 - a) Collectibles
 - b) Real Estate
 - c) Human Capital
 - d) IP rights
 - e) ...
- 4) What other projects and typical use cases do you know?
 - 1) Track and tracing in logistics
 - 2) Infrastructure for asset settlement
 - 3) ...

IV. Concluding remarks

1. What are your final thoughts on tokenization?
2. Are you interested in receiving the results of our study?
3. Do you know of any other potential participants for our study?

Thank you for your time and participation

Appendix D.3: Overview of Archetypes and Sub-criteria (1/2)

Appendix D.3: Overview of Archetypes and Sub-criteria (2/2)

Appendix E: Conceptual Model

Appendix E.1: Initial Concept Matrix of the Conceptual Model (1/2)

Reference	Technical architecture	Conceptual framework	Classificatory framework	Theoretical aspects	Internet of Things	Practical implementation	Basic use case description	OSI model components	Business model layer	Governance layer	Inter-organizational layer	Service layer	Process layer	Value chain roles	Platform or ecosystem	DLT comparison	Tokenization use case	Custody of digital assets	Environmental aspects
(Abreu et al. 2020)	X					X	X												
(Ali Syed et al. 2019)		X			X	X						X			X	X			
(Allen et al. 2020)																			X
(Alsindi & Lotti 2021)												X							
(Antal et al. 2021)	X							X									X	X	
(Bear et al. 2020)												X		X					
(Beck et al. 2018)				X						X									
(Bhutta et al. 2021)								X									X		
(Bouraga 2021)			X														X		
(Büyükoğkan & Tüfekçi 2021)															X	X			
(Che et al. 2019)	X					X	X					X							
(Choudhury & Weisman 2021)	X												X						
(Cœuré et al. 2020)													X						
(Conway & Garimella 2020)										X					X				
(de Kruijff & Weigand 2017)	X													X					
(De Rossi et al. 2019)		X					X		X	X		X							
(Deloitte Legal 2018)																			X
(Deubel et al. 2017)													X						X
(Dinh et al. 2018)			X			X	X					X					X		
(Du et al. 2020)		X						X					X	X	X	X	X		
(Du et al. 2021)		X											X	X	X				
(Eickhoff et al. 2017)												X							
(Ferreira et al. 2021)																			X
(GVTG 2019)														X					
(Glaser & Bezenberger 2015)			X									X					X		
(Glaser 2017)		X						X				X			X				
(Han et al. 2019)		X										X	X	X			X		
(Henning 2018)																		X	X
(Hirtschulz et al. 2019)																		X	X
(Homoliak et al. 2021)		X						X									X		
(Ismail & Materwala 2019)							X	X						X			X		X
(Jayasuriya & Sims 2021)																	X	X	
(Kannengießler et al. 2020)	X																X		
(Labazova 2019)		X	X							X		X			X	X			
(Labazova et al. 2018)	X	X																	
(Lai et al. 2021)												X	X	X					
(Lao et al. 2020)					X			X									X		
(Latif et al. 2021)	X				X	X		X											
(Li et al. 2021)		X						X				X			X	X			
(Liu et al. 2021)										X									

Appendix E.1: Initial Concept Matrix of the Conceptual Model (2/2)

Reference	Technical architecture	Conceptual framework	Classificatory framework	Theoretical aspects	Internet of Things	Practical implementation	Basic use case description	OSI model components	Business model layer	Governance layer	Inter-organizational layer	Service layer	Process layer	Value chain roles	Platform or ecosystem	DLT comparison	Tokenization use case	Custody of digital assets	Environmental aspects
(Lu et al. 2019)	X	X			X							X							
(Lu et al. 2021)	X	X			X								X				X		
(Mackey et al. 2019)		X															X		
(Mazzei et al. 2020)	X				X	X													
(Millard, 2018)																			X
(Moin et al. 2019)		X			X	X		X											X
(Mougayar & Vitalik 2016)												X							
(Nanayakkara et al. 2021)															X	X			
(Notheisen et al. 2017)		X									X	X		X	X				
(Notheisen et al. 2019)			X						X						X	X	X		
(Okada et al. 2017)										X					X	X			
(Pang et al. 2020)												X	X	X					
(Paulavicius et al. 2019)								X								X			
(Perscheid et al. 2020)										X									X
(Plazibat 2019)	X																		
(Pohl et al. 2020)		X													X	X	X		
(Qing et al. 2020)		X						X				X							
(Rauchs et al. 2018)	X	X	X						X	X					X	X	X		
(Riasanow et al. 2018)		X									X				X	X			
(Rossi et al. 2019)		X		X															
(Salmon & Myers 2019)																			X
(Schär 2021)	X											X							
(Seebacher & Maleshkova 2018)		X					X		X		X	X		X	X				
(Shah et al. 2019)																			X
(Stefanoski et al. 2020)												X	X	X					
(Tasca & Tessone 2018)		X	X				X					X				X	X		
(Tian et al. 2020)													X	X					
(Trautman 2016)												X	X						
(Truong et al. 2021)					X	X		X				X							
(Venkatesh et al. 2020)		X			X			X				X	X	X					
(Wang et al. 2019)		X										X							
(Wang et al. 2020)		X										X							
(Xu et al. 2017)	X		X														X		
(Xu et al. 2019)	X											X							
(Yee Loong Chong et al. 2019)									X										X
(Yiwei et al. 2021)		X				X						X	X	X					
(Zachariadis et al. 2019)										X									
(Zavolokina et al. 2020)										X					X				
(Zhang, Zhong et al. 2020)		X										X		X					
(Zhang, Tan et al. 2020)		X						X				X			X				
(Zhang, Tian et al. 2021)	X	X											X	X		X	X		
(Zheng et al. 2019)												X							
(Zutshi et al. 2021)		X					X	X	X			X							

Appendix E.2: Overview of Case Study Meetings

Case Study Meeting	Company	Venue	Duration	Date	Description
A	Amazing Blocks	Virtual	42 Min	05.07.21	Introduction to the problem domain, presentation of the model, challenging of model elements
B	StokenX	Virtual	76 Min	07.07.21	Introduction to the problem domain, presentation of the model, challenging of model elements
C	BEKB	Virtual	59 Min	13.07.21	Introduction to the problem domain, presentation of the model, challenging of model elements
D	NYALA	Berlin (DE)	91 Min	13.07.21	Introduction to the problem domain, presentation of the model, challenging of model elements
E	Amazing Blocks	Virtual	41 Min	26.08.21	Challenging of prior results, refinement of the model, and evaluation
F	StokenX	Virtual	94 Min	30.08.21	Challenging of prior results, refinement of the model, and evaluation
G	SIX	Virtual	80 Min	30.09.21	Presentation of the model, challenging and refinement of model elements, and design evaluation
H	Bank Frick	St.Gallen (CH)	96 Min	18.10.21	Presentation of the model, challenging and refinement of model elements, and design evaluation
I	Daura	Virtual	35 Min	20.10.21	Presentation of the model, challenging and refinement of model elements, and design evaluation
J	BEKB	Virtual	43 Min	09.11.21	Challenging of prior results, refinement of the model, and evaluation
K	NYALA	Virtual	40 Min	30.11.21	Challenging of prior results, refinement of the model, and evaluation
L	NYALA	Berlin (DE)	75 Min	16.02.22	Demonstration and application of the conceptual model to develop a value architecture as a company-specific asset tokenization business model.
M	BEKB	Virtual	78 Min	17.02.22	Demonstration and application of the conceptual model to develop a value architecture as a company-specific asset tokenization business model.

Appendix E.3: Excerpt of the Case Study Interview Guide (1/2)

Interview Guide: A conceptual framework for the description of asset tokenization ecosystems

Thank you for your interest to participate in our 45 min. interview based on the five parts of our proposed model. This is an exploratory study with no wrong answers. The results are part of a case study, and the findings will be processed anonymously.

Background

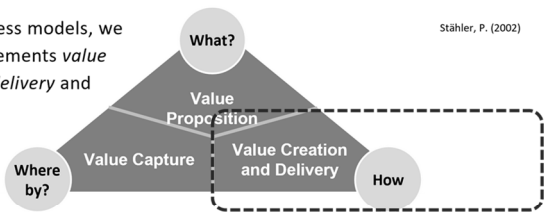
The concept of tokenization has emerged in recent years using DLT to enable the transfer of asset ownership in decentral manner. It initially describes the process of creating a token on a shared ledger in terms of a singular identifier that enables a unique and persistent reference. As everything may be represented by creating such reference, we define a token as a cryptographically secured digital representation of value or contractual rights. By adding individual properties of assets into a token, it can be designed to be unique, tradeable, scarce, and much more.

Although feasibility of asset tokenization has been broadly tested and proven, real-world adoption has not kept pace with the number of investments and announced projects. It is assumed that existing practices cannot guide organizations through the business, process, and technological changes necessary to implement and scale decentralized platforms. Especially for business architects, guidance is required to successfully interact with these innovative infrastructures.

To provide an abstract foundation, we want to identify relevant components for the description of asset tokenization ecosystems. The goal is to develop a high-level framework indicating different layers (e.g., roles, services, governance, DLT-protocols) and facilitate the setup of this innovation as part of a shared business or operating model. Accordingly, the framework may serve as a starting point for practicable solutions and further research in a token-economy.

To describe tokenization business models, we differentiate between three elements *value proposition*, *value creation & delivery* and *value capture*

Stähler, P. (2002)



I. Demographics

Position/ Job Titel	Field of activity
Industry / Company	Number of employees

DLT Experience

Since when are you involved in DLT?

Years of Experience

What are your experiences with DLT?

For example: Crypto trading, DApp development,

How would you rate your knowledge of DLT and asset tokenization?	No knowledge	Limited knowledge	Medium knowledge	High knowledge	Very high knowledge
	☐	☐	☐	☐	☐

Appendix E.3: Excerpt of the Case Study Interview Guide (2/2)

Asset tokenization ecosystem framework

II. Evaluation of the overall Asset Tokenization Framework

Please reflect your asset tokenization case by applying the framework and evaluate its utility:

1 Completeness: The conceptual framework is complete, there are no redundant nor missing elements.

Strongly disagree

☐

Disagree

☐

Agree nor disagree

☐

Agree

☐

Strongly agree

☐

Comment

2 Real world fidelity: The framework realistically represents relevant elements for description.

Strongly disagree

☐

Disagree

☐

Agree nor disagree

☐

Agree

☐

Strongly agree

☐

Comment

3 Consistency: The conceptual framework is internally consistent and logically stringent.

Strongly disagree

☐

Disagree

☐

Agree nor disagree

☐

Agree

☐

Strongly agree

☐

Comment

4 Level of detail: The conceptual framework has an appropriate level of detail.

Strongly disagree

☐

Disagree

☐

Agree nor disagree

☐

Agree

☐

Strongly agree

☐

Comment

5 Robustness: The conceptual framework is robust and applicable in practice.

Strongly disagree

☐

Disagree

☐

Agree nor disagree

☐

Agree

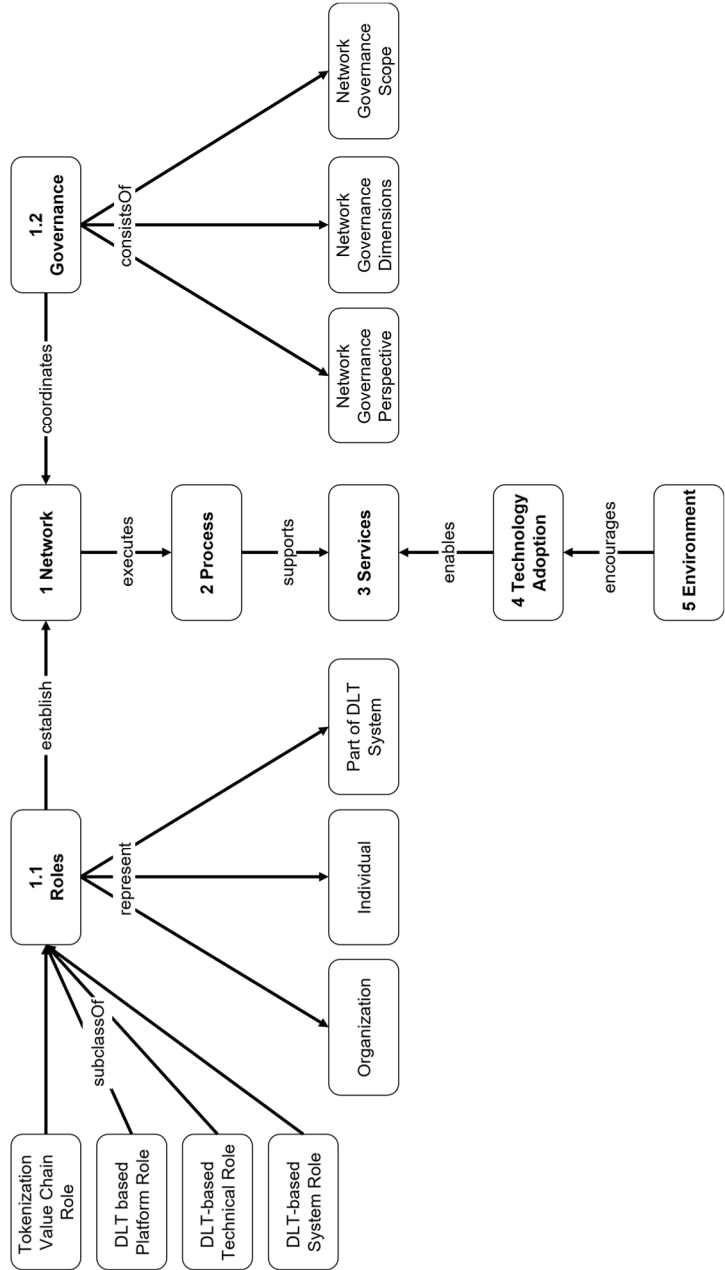
☐

Strongly agree

☐

Comment

Appendix E.4: Model Elements and their Relationships



Appendix F: Organizational Principles

Appendix F.1: Excerpt of Organizational Change Interview Guide (1/2)

Decentralized Applications and Their Impact on Intra-Organizational Structures of Firms

Interview Guide

Dear participant,

Thank you for your interest and time to participate in our **study on firms' intra-organizational changes caused by using decentralized applications (DApps)**. The study will take **approx. 45 min** of your time. The interview is structured in four parts: *demographics, challenges & potentials of DApps, impact of using DApps, and concluding remarks*.

This is an explorative study and there are no wrong answers. Your answers will be kept confidential and insights from the semi-structured interview will be published in aggregated and anonymous form.

Motivation

Today's firms support inter-organizational and intra-organizational business processes **mainly using centralized software applications**. Usually, a trusted party (e.g., external IT providers or the firms themselves) is responsible for the operation of these software applications. Centralized software applications and trusted parties represent **single-point-of-failures** that can cause **challenges for the interaction, collaboration, and cooperation between firms**, including heterogeneous and opaque business processes and information asymmetries that diminish trust between collaborating partners.

Distributed ledger technology (DLT) is promising to mitigate these challenges to a certain degree by replacing trusted parties by a fraud-resistant and decentralized distributed database (i.e., distributed ledgers). Thereby, DLT allows to **reduce risks** caused by opportunistic behaviour of individual firms in value creation networks, to **increase transparency** of business processes, and even to **develop new business models** (e.g., escrow services in supply chain management). Using DApps (i.e., software applications that implement a distributed ledger), firms can directly interact with each other with **no trusted party** (e.g., for the transfer of asset ownership) and can **avoid single-point-of-failures** (e.g., regarding downtimes of software applications or censorship).

DApps also introduce new and yet unresolved challenges for firms that require **changes to established IT management** approaches (e.g., regarding **IS sourcing**). These changes affect firms' external relations and business processes (e.g., regarding **IT governance**), which also interrelate with their intra-organizational structures. For example, the joint operation of a decentralized infrastructure in cooperation with other firms (i.e., inter-organizational) **requires individual firms to build competencies** for decentralized governance (i.e., intra-organizational). Nonetheless, it is still unclear how using DApps will affect firms' intra-organizational structures. To understand required changes to intra-organizational structures caused by using DApps, we aim to identify the effects of using DApps on firms' intra-organizational structures in semi-structured interviews with experts from the industry.

If you have any questions or concerns regarding the study, feel free to contact us via e-mail.

Kind regards,

Roger Heines (roger.heines@bei-sg.ch)

Niclas Kannengießer (niclas.kannengießer@kit.edu)

Appendix F.1: Excerpt of Organizational Change Interview Guide (2/2)

Interview Guide

I. Demographics

Position/ job title	Field of activity
Company type	Number of employees

DLT Experience

Since when are you involved in DLT?

Years of Experience

What are your experiences with DLT?

For example, cryptocurrency trading, DApp development,...

Prior Knowledge of DApps¹How would you rate your knowledge of DLT or DApps¹?

No knowledge	Limited knowledge	Intermediate knowledge	High level of knowledge	Very high knowledge
☐	☐	☐	☐	☐

Domain

In which domain are you mainly involved?

For example, automotive, finance,...

II. Challenges and Potentials of DApps¹

- I. What are use cases, initiatives, or projects for DApps¹ currently operating or under discussion in your company or consortium?
- II. What are the challenges of centralized software applications in your field to support business processes? How could DApps¹ help to overcome these challenges?

Name	Challenge	Solution
Third party dependence	The operation of the software applications depends on a single party and its technical capabilities.	The decentralized operation of a digital platform in a consortium can decrease the dependence and impact of single parties.
Cross-organizational process automation	Existing information systems mainly enable automation of business processes within firms but are prone to manipulation and, thus, are not suitable for cross-organizational process automation.	Smart contracts can help to reliably automate business processes, while assuring traceability and enabling auditability.

- III. Please choose a use case for a DApp¹. Explain what tasks the DApp handles and why using a DApp is reasonable in your use case.

¹Software applications that build upon a distributed digital platform (e.g., a distributed ledger) that does not implement a central authority to manage the individual computing nodes operating the digital platform.

Appendix F.2: Overview of Challenges and Descriptions (1/2)

TOE	Theme	Definition	Sub-Theme (Challenge)	Descriptions
Technology	IT System Engineering	The challenges developers face related to designing, implementing, and operating a decentralized IT system	Developer Support	The low level of support for developers when implementing business logic (e.g., unsuitable programming languages)
			DLT Protocol Configuration	The increased number of relevant trade-offs between technology characteristics that hinder the provision of a suitable protocol for a specified IT system
			Software Testing	The large number of characteristics of a DLT system that prevent full software test coverage (e.g., connected off-ledger software and lack of software testing tools).
			Technological Maturity	The low availability of theoretical and practical knowledge about the effective design and usage of decentralized IT systems
			Interoperability Assurance	The increased difficulty of integrating new or maintaining existing system components so that they interact with existing system components
	Administration and Coordination	Challenges associated with the processes in the administration of system components, maintaining the source code, and managing application programming interfaces	IT System Administration	The amount of additional work required to administrate IT systems (partially) operating on decentralized platforms
			Source Code Base	Higher dependency on third-party technology providers (e.g., a cryptocurrency wallet or cloud provider) with a closed source code base
			Management of Cryptographic Keys	The additional effort required to manage and organize the generation, custody, and use of cryptographic keys required to interact with an IT system (e.g., a distributed ledger)
	User-Centered Application Design	Challenges in application design for end-user to efficiently achieve their goals with a decentralized solution	Usability	The difficulties consumers face in using decentralized solutions to achieve a particular goal

Appendix F.2: Overview of Challenges and Descriptions (2/2)

TOE	Theme	Definition	Sub-Theme (Challenge)	Descriptions
Organization	Leadership and Organizational Culture	Challenges for driving a required culture change associated with the norms, attitudes, and behavior of employees to support the transformation towards decentralized IS	Acceptance	The lack of employee willingness to react and adapt to changes promptly and appropriately (e.g., a new business process)
			Understanding	The insufficient knowledge within (parts of) the organization about decentralization and the technology (to be) used for establishing a decentralized ecosystem
Environment	Revenue	Challenges associated with strategic decisions for participating in a decentralized ecosystem and use cases involving the commitment of funds and shared resources	Cost	Operational costs are challenging to estimate due to their dependency on factors that an organization cannot control (e.g., transaction fees)
			Demand	The lack of demand for offerings of decentralized ecosystems (e.g., cryptocurrencies or supply chain tracking information) by ecosystem stakeholders
			Stakeholder Incentives	The challenges faced in designing decentralized ecosystems under consideration of benefits for each stakeholder of the ecosystem and their use case
			Information Advantage	The loss of competitive advantage of firms caused by information sharing by participating in a decentralized ecosystem
	Governance	Challenges in establishing and maintaining the decentralized ecosystem according to the enforcement of decision rights and accountabilities of a decentralized IS	Stakeholder Coordination	The additional efforts of initiating and coordinating a decentralized ecosystem and associated activities such as coordination, communication, and resource allocation between stakeholders (e.g., on-boarding)
			Corporate Responsibility	The impact of strategic decision making related to business activities on society, employees, and the environment
			Compliance Efforts	The increased effort involved in identifying and meeting regulatory obligations
			Network Topology Standardization Efforts	Nontrivial decisions on node operation responsibilities with unclear consequences for entities and processes The difficulties involved in coming to an agreement between multiple stakeholders on a set of standards for establishing a decentralized ecosystem

Appendix F.3: BIAN Service Landscape (<https://bian.org>)

Reference Data				Sales & Service				Operations & Execution				Analytics				Business Support							
Party	Party Data Management			Channel Specific	Marketing			Consumer Products	Financial Markets			Corporate Products	Bank Portfolio & Treasury			IT Management	Finance						
	Party Profile				Sales				Investment Management				Trade Finance				Human Resource Management						
	External Agency				Cards				Consumer Loans & Deposits				Corporate Banking Products				Non IT and HR Enterprise Services						
External Agency	Agency Management			Cross Channel	Consumer Services			Consumer Loans & Deposits	Market Operations			Operational Services	Regulations & Compliance			Business Planning	Buildings, Equipment and Facilities						
	Agency Profile				Market Operations				Wholesale Trading				Account Management				Business Command & Control						
	Agency Data Management				Payments				Consumer Products				Collateral Administration				Document Mgmt & Compliance						
Channel Specific	Channel Management			Cross Channel	Collection			Consumer Loans & Deposits	Cross Product Operations			Operational Services	Regulations & Compliance			Business Planning	Buildings, Equipment and Facilities						
	Channel Profile				Payments				Consumer Products				Regulations & Compliance				Buildings, Equipment and Facilities						
	Channel Data Management				Collection				Consumer Products				Regulations & Compliance				Buildings, Equipment and Facilities						
Cross Channel	Cross Channel Management			Cross Channel	Collection			Consumer Loans & Deposits	Cross Product Operations			Operational Services	Regulations & Compliance			Business Planning	Buildings, Equipment and Facilities						
	Cross Channel Profile				Payments				Consumer Products				Regulations & Compliance				Buildings, Equipment and Facilities						
	Cross Channel Data Management				Collection				Consumer Products				Regulations & Compliance				Buildings, Equipment and Facilities						
Product Management	Product Management			Cross Channel	Collection			Consumer Loans & Deposits	Cross Product Operations			Operational Services	Regulations & Compliance			Business Planning	Buildings, Equipment and Facilities						
	Product Profile				Payments				Consumer Products				Regulations & Compliance				Buildings, Equipment and Facilities						
	Product Data Management				Collection				Consumer Products				Regulations & Compliance				Buildings, Equipment and Facilities						

Appendix F.4: Screenshot of the Website for Artifact Evaluation

