2023

Factors driving enterprise adoption of blockchain technology

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FACTORS DRIVING ENTERPRISE ADOPTION OF BLOCKCHAIN TECHNOLOGY

A dissertation submitted in partial fulfillment

of the requirements for the degree of

DOCTOR OF BUSINESS ADMINISTRATION

by

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August, 2023

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This dissertation, written by

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under the guidance of a Dissertation Committee and approved by its members, has been submitted to and accepted by the Pepperdine Graziadio Business School in partial fulfillment of the requirements for the degree of

DOCTOR OF BUSINESS ADMINISTRATION

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TABLE OF CONTENTS

LIST OF TABLES VII

LIST OF FIGURES VIII

DEDICATION IX

VITA X

ABSTRACT XI

CHAPTER 1: INTRODUCTION 1

OVERVIEW 1

PROBLEM ADDRESSED 2

RESEARCH QUESTIONS 5

SIGNIFICANCE OF THE PROPOSED RESEARCH 5

CHAPTER 2: OVERVIEW OF THE RESEARCH AREA AND APPROACH 7

INTRODUCTION 7

FOUNDATIONAL LITERATURE REVIEW 7

DESCRIPTION OF THE RESEARCH AGENDA 12

JUSTIFICATION OF THE RESEARCH AGENDA AND APPROACH 13

CHAPTER 3: A TAXONOMY MATRIX OF ENTERPRISE BLOCKCHAIN TECHNOLOGY DESIGN AND USE CASES 18

INTRODUCTION 18

RELATED RESEARCH 19

RESEARCH APPROACH, TAXONOMY DEVELOPMENT 25

ANALYSIS AND RESULTS: TAXONOMY TO MATCH BT WITH USE CASES 28

Taxonomy of Enterprise Blockchain Technology Characteristics 29

Taxonomy of Enterprise Use Case Characteristics.. 41

GUIDANCE USING THE TAXONOMY MATRIX 48

APPLICATION OF THE TAXONOMY 50

DISCUSSION AND CONTRIBUTIONS 54

LIMITATIONS AND FUTURE RESEARCH 56

CONCLUSIONS 57

CHAPTER 4: FACTORS LEADING TO ADOPTION WITH CONTINUED USE IN LARGE ENTERPRISES 59

INTRODUCTION... 59

LITERATURE REVIEW 60

Blockchain Technology.. 60

Technology Adoption 63

RESEARCH METHODOLOGY... 67

STUDY POPULATION AND SAMPLING... 68

DATA COLLECTION AND ANALYSIS.. 70

CASE STUDIES OF BLOCKCHAIN TECHNOLOGY PROJECTS... 72

Case Study Organization & Process 72

Birra Peroni.. 74

ANSA.. 78

Takeda 81

Aretaeio 85

Microsoft Xbox ... *88*

Enterprise Use Case Failure ... *92*

RESULTS ... 94

Technological ... *95*

Organizational ... *96*

Environmental and Inter-organizational ... *97*

DISCUSSION AND THEORETICAL PROPOSITIONS ... 97

PRACTICAL IMPLICATIONS ... 103

CONCLUSIONS ... 105

CHAPTER 5: CONCLUSIONS AND IMPLICATIONS ... 108

IMPLICATIONS FOR ADVANCING THEORY ... 108

IMPLICATIONS FOR BUSINESS PRACTICE ... 110

LIMITATIONS AND RECOMMENDATIONS FOR FUTURE RESEARCH ... 112

CONCLUSION ... 114

REFERENCES ... 117

APPENDIX A: IRB APPROVAL LETTER ... 122

APPENDIX B: SEMI-STRUCTURED INTERVIEW GUIDE ... 123

APPENDIX C: TAXONOMY MATRIX EXPLANATION OF SUITABILITY AND UNSUITABILITY COMBINATIONS ... 125

LIST OF TABLES

Table 1. Taxonomy Ending Conditions ……………………………………………………………26

Table 2. Description of Case Studies……………………………………………………………69

Table 3. Dimensions and Factors of Blockchain Adoption…………………………….........95

LIST OF FIGURES

Figure 1. A Framework for Blockchain Case Study Research……………………..…………16

Figure 2. The Taxonomy Development Method…………………………………...……...….23

Figure 3. Taxonomy Approach for Blockchain Applications……………………………………24

Figure 4. Taxonomy Matrix of Enterprise Blockchain Technology Design and Use Cases…… 49

Figure 5. The Innovation Decision Process…...……………………………………………64

DEDICATION

I dedicate this research to my mother, Sharon Marshall, and my late father, "Surfer" Joe Foster. Few children are lucky enough to have two incredible parents supporting and cultivating passions and pursuits. Without their unconditional love, I would not be the man I am today. I am forever grateful and know dad is smiling down from heaven proud of his son.

VITA

Matthew Foster is Director of Technology Strategy & Innovation at Amgen, a leading global biotechnology company. Matthew focuses on emerging technologies with the potential to significantly disrupt value chains across industries. He spearheads a portfolio of innovation efforts that spans quantum computing, blockchain technology, federated machine learning, and generative AI. Matthew has 20 years of experience spanning depth in business strategy, operations, and mergers & acquisitions. This experience includes almost 10 years in strategy consulting at EY and KPMG, as well as focused energy industry roles with Constellation Energy and PowerAdvocate. Matthew began his career in the nuclear engineering domain, serving as an officer in the United States Navy.

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ABSTRACT

Amidst the rapidly evolving advancement of blockchain technology (BT), enterprises face notable challenges in leveraging its transformative potential, starting with a need to understand the technology and how it can be used for particular applications. Two challenges are that many BT trials have not been successful and large-scale implementations that have led to continued use are scarce. This research provides a comprehensive examination of factors that drive the successful adoption of BT for enterprise use cases. A dual-phased approach was employed. First, I introduce a taxonomy matrix correlating BT design characteristics with use case characteristics, offering a framework for BT design and benefits across different enterprise contexts. Second, I conducted case studies of five successful BT cases in large enterprises that led to the adoption in terms of continued use and contrasted them with one failure case. The data collection and analysis of the case studies encompassed technological, organizational, environmental, and inter-organizational variables that led to BT's continued use. The cross-case analysis revealed that compatibility, relative advantage, and observability are primary technological factors contributing to continued use. Within the organizational dimension, organizational knowledge and internal characteristics emerged as crucial elements, while regulatory compliance came out to be a significant factor. Based on the cross-case analysis, I develop theoretical propositions about the factors that lead to the continued use of BT, which can be further validated and tested in future research.

Keywords: technology adoption, blockchain, innovation, taxonomy

CHAPTER 1: INTRODUCTION

Overview

Five years into the public availability of the world wide web (WWW), Metcalf (1995) then famously proclaimed, "I predict the internet will soon go spectacularly supernova and in 1996 catastrophically collapse" (p. 61). Now we can see the humor in that innocuous line with almost every facet of our lives dominated by technological connection and communication through the internet and the WWW.

Blockchain technology (BT) represents the internet of value as opposed to the internet of information. Alternatively, some see blockchains as part of web 3.0, a decentralized, read-write-execute web that is fundamentally different from web 1.0 (the read-only web, used to search for information) and web 2.0 (the read-write web of user-generated content). Blockchains have also been portrayed as part of the fourth industrial revolution, following the revolutions inspired by steam, electricity, and information technology. BT may represent a technological revolution, but new techno-economic paradigms do not establish themselves overnight (O'Dair, 2018).

Unlike TCP/IP emerging as dominant internet protocol during the protocol wars of the 1970's, the design of any blockchain protocol currently cannot support all transactions that potentially benefit from BT. Characteristics of use cases require certain blockchain design characteristics to achieve desired outcomes for all stakeholders involved in the respective use case. New BT use cases are introduced frequently and, with many more expected in the future, developing a framework is needed to guide potential BT adopters on which type of blockchain is best suited for the respective purposes (Risius & Spohrer, 2017).

Blockchain, a revolutionary technology first introduced through Bitcoin in 2008, has been defined as a "digital, decentralized and distributed ledger in which transactions are logged and added in chronological order with the goal of creating permanent and tamper-proof records" (Treiblmaier, 2018, p. 547). Implications for the storage and transfer of value through Bitcoin and other cryptocurrencies are enormous. As Dalio (2020) notes, economic cycles tend to happen every 60-80 years. The last major shift in reserve currency was the 1971 announcement from President Nixon stating the U.S. dollar would no longer be pegged to gold, therefore effectively rendering the Bretton Woods system inept. The growing inability of the U.S. Federal Government and the U.S. Central Bank to work in tandem to both curb the spiraling debt and maintain a healthy real economy is leading to calls for the next reserve currency to be identified. Some are preparing for Bitcoin as a decentralized inevitability, changing from the control of a central authority manipulating monetary policy to orchestrate macroeconomic conditions. However, BT has now found its way beyond digital currency and into the realm of business models, processes, and inter-organizational network facilitation.

Problem Addressed

As BT continues to gain attention and interest in various industries, enterprises worldwide are exploring its potential for practical applications. The unique characteristics of BT offer great potential to foster various sectors through decentralization, immutability, and transparency (Casino et al., 2018). These BT features signify a potential for significant disruption for many different business processes and industries. However, little is known regarding which features are relevant for particular use cases and how they need to be designed (Risius & Spohrer, 2017). As recently as 2020, over 80% of enterprises considered blockchain important as a strategic priority, yet only 39% reported deployment of a use case into production (Pawczuk et al., 2020). Enterprises face numerous challenges in realizing the optimal benefits of BT adoption, resulting in a significant gap between interest and actual technology implementation.

One major challenge lies in identifying the appropriate blockchain design characteristics for their particular use cases. For any blockchain design characteristic, numerous technological options have been developed. For instance, consensus provides block finality, which determines if the information stored on the chain can be considered perpetually stored once the block has been added to the chain. Consensus designs include over 30 alternatives since proof-of-work (i.e., a consensus mechanism used by many cryptocurrencies to validate transactions on their blockchains and award tokens for participating in the network) was introduced with the advent of Bitcoin (Nakamoto, 2009). Given this diversity of blockchain protocols, organizations must consider numerous technological options to suit their specific needs and carefully evaluate the advantages and disadvantages of each design characteristic to make informed decisions, a particularly challenging task for emerging technologies. The absence of a framework that connects blockchain design characteristics with use case characteristics makes it difficult for potential BT adopters to make the right choices regarding technology selection and adoption.

Another challenge organizations encounter is the lack of understanding of the critical factors influencing the successful adoption of BT at the enterprise level (Sanka et al., 2021). Current research on technology adoption primarily focuses on general technology adoption theories and conceptual models, such as the Technology, Organization, Environment (TOE) model and Roger's (2003) Diffusion of Innovations (DOI) theory. While these frameworks provide valuable insights into various aspects of technology adoption, they often fail to address the specific nuances and complexities of BT adoption, which includes other factors not often requiring consideration in the domain, such as inter-organizational complexities of an ecosystem technology.

The regulatory environment surrounding BT adds another layer of complexity to successful BT adoption. The uncertain and evolving regulatory landscape in many countries generates challenges for enterprises in areas such as cryptocurrency usage, governance structures, and data privacy. This uncertainty can inhibit organizations from fully leveraging BT's potential or deter them from exploring the technology altogether (Ali et al., 2020).

Finally, there is a lack of practical guidance rooted in empirical evidence from real-world BT adoption experiences. Enterprises seeking to adopt BT can significantly benefit from the learning and success stories of early BT adopters, particularly those who have managed to overcome the challenges and barriers facing BT implementation. However, limited research has been conducted on the experiences of these early adopters, and their insights have not been consolidated into actionable principles for other enterprises to follow. As a result, enterprises often struggle to navigate the complexities of BT adoption, leading to a lack of standardized adoption practices and, ultimately, less effective implementation of BT in the business environment resulting in use cases not meeting desired outcomes, or worse, failure.

This research addresses these challenges head on and contributes to the body of knowledge on BT adoption by establishing a comprehensive framework that connects blockchain design characteristics with use case characteristics while also examining the factors that impact the successful enterprise-level adoption of BT. By combining the taxonomy presented in Chapter 3 of use case meta-characteristics and conducting an empirical study on multiple organizations' BT adoption in Chapter 4, my research provides practical guidance for potential BT adopters and sheds light on the underlying success factors in the enterprise context. Ultimately, this research contributes to the broader understanding of BT adoption and facilitates accelerated global blockchain value realization across industries.

Research Questions

The problems described previously highlight an academic literature gap between enterprise-level interest in BT and its actual adoption into enterprise technology stacks and business processes. Recognizing the critical role of appropriate design characteristics and understanding the factors influencing successful BT adoption, this research bridges this gap through the development of a comprehensive framework and generating practical insights from the experiences of early adopters. Specifically, to guide enterprises looking to adopt BT, I aim to answer the following research questions:

- RQ1: What blockchain design characteristics are best suited for respective use case characteristics?
- RQ2: What are the technological, organizational, environmental, and inter-organizational factors that lead to successful enterprise-level adoption of blockchain technology?

To match blockchain design characteristics with use case characteristics (RQ1), I developed a taxonomy matrix of both design and use case meta-characteristics in an enterprise context. To develop factors leading to the successful adoption of BT (RQ2), I leveraged a multiple case-study approach to compare organizations that have adopted BT and continued use of at least one use case.

Significance of the Proposed Research

The BT domain represents a new type of technology that crosses beyond traditional technology adoption, and because of its inherent decentralized characteristics, forces enterprises to consider other dimensions when selecting and adopting it. For instance, enterprises can be governance nodes that validate data, yet some blockchain designs require payment in native cryptocurrency, an area of regulatory uncertainty across the world. Some blockchain solutions have introduced innovative technical solutions like VeChain’s Multi-Payment Protocol, which allows one party to pay the fee for transaction costs, so users can receive value from the blockchain without ever having to hold native cryptocurrency.

Proper technology design is a key factor for adoption and continued use. Current research focuses on general blockchain features, often in the form of a conceptual model. While helpful to frame enterprise motivation for consideration of BT as an innovation to adopt, Risius and Spohrer (2017) conclude that previous work on enterprises and industries has provided extensive frameworks and starting points for future research to advance research in a structured and impactful fashion. A sophisticated consideration of the different blockchain features (e.g., permission level, data access, transaction consensus, modularity, scalability, interoperability, centralization, and anonymity) is required to advance the macro-adoption of BT (Walsh et al., 2016).

My research agenda serves to provide practical guidance derived from the early enterprise adopters of BT to enterprises seeking to extract the value of BT across any number of use cases. It is my belief that at this early stage of the adoption lifecycle, highlighting the success factors is more important than generating a list of failure factors. Thomas Edison is attributed to saying, “I have not failed. I have just found 10,000 ways that won’t work.” Similarly, early BT adoption has witnessed numerous ways to fail, which is why there are so few scaled adoption success stories to date. Studying the few that have succeeded and isolating the factors allowing longitudinal success will serve as a lighthouse to accelerate BT adoption. For increased validity, I studied one failure as a contrasting benchmark to better understand successes.

The enterprise is the unit of analysis for my research. The blockchain domain has seen a rapid increase in adoption at the individual level, driven by new consumer business models, such as decentralized finance (defi) and non-fungible tokens (NFT). Traditional enterprise use cases often involve business ecosystem complexities and multi-stakeholder governance. Unlocking insights about successful enterprise adoption can accelerate global blockchain value realization.

CHAPTER 2: OVERVIEW OF THE RESEARCH AREA AND APPROACH

Introduction

Unlocking the promise of BT value requires understanding its successful adoption within enterprises. Several academic research dimensions emerge as critical anchors for my research. This dissertation delves into the comprehensive landscape of the technology adoption literature, highlighting established theoretical frameworks such as the TOE model (Tornatzky & Fleischer, 1990) and Roger's (1995) DOI theory to characterize the unique challenges presented by BT adoption. Insights provided by these existing frameworks were aimed at uncovering factors influencing successful enterprise implementation and continued use of BT.

The dissertation employs a two-step methodology that combines taxonomy development and case study research to enhance our understanding of BT adoption at the enterprise level and to offer valuable, practical guidance for potential technology adopters, ultimately contributing to the global discourse on blockchain adoption.

Foundational Literature Review

Technology adoption is a relatively mature domain, including over 20 theoretical frameworks applied to varying units of analysis across industries. The construct adoption as a dependent variable (DV), however, has taken several forms across the literature. Early BT adoption literature focuses on the catalyst for behavioral intention to adopt a technology. More recently, studies have focused on other forms of adoption, including actual system use, continuance of use, and mixed-use, which includes any study taking two or more definitions of adoption. This study seeks to develop the principles required for the successful adoption and scaled implementation of BT. Therefore, the working definition of adoption focuses on the continuance of use. Continuance of use can be defined as a person or organization deciding to continue to use or adopt an innovation in the future (Rad et al., 2017).

Rogers (1995) provided landmark research on the diffusion of innovations, including technological innovations. He states that in an organization, technology adoption is "a decision to make full use of an innovative IT as the best course of actions available" (Rogers, 1995, p. 61). Rogers' DOI theory identified four critical elements in the diffusion process: the innovation, its communication from one individual to another, the social system, and time. He also introduced the well-known bell curve notated by categories of adopters: innovators, early adopters, early majority, late majority, and laggards. The rate of adoption (curve slope) is impacted by five factors: relative advantage, compatibility, trialability, observability, and complexity. Rogers, and the majority of literature that spans technological innovation diffusion, took a consumerist unit of analysis (Rad et al., 2017). Researching the organizational level of early adoption requires different factors to be considered to consider the complexities across innovation adoption intention and use. DOI has been leveraged widely in the technology adoption domain over the last 20 years (Chiu et al., 2017).

Many theoretical constructs have been developed to explain technology adoption and use. Venkatesh et al. (2003) attempted to leverage eight previous models to theorize technology adoption in enterprises. The result was the Unified Theory of Acceptance and Use of Technology (UTAUT). According to UTAUT, four main factors influence the intention and usage of technology. Performance expectancy is the degree of belief using the technology will help attain gains in organizational performance. Effort expectancy is the degree of ease associated with use. Facilitating conditions are degrees of organizational and technical infrastructure support. Finally, social influence is the degree of perception that others believe the use of technology.

While BT is a nascent technology, the domain of technology selection, adoption, and use is in an intermediate state. Early models such as TAM are still utilized today and applied to specific technology adoption areas (Zheng & Li, 2020). Alignment on the maturity level of technology adoption remains elusive due to the lack of consensus on a unified technology adoption theory that most researchers will agree on.

Another alternative adoption theory is the TOE model (Tornatzky & Fleischer, 1990). The TOE model addresses technology adoption at the enterprise level and has been proven to be effective (Zhu et al., 2006). The TOE model focuses on three categories to explain technology adoption; the technological category includes the characteristics and usefulness of the technology, the organizational category explores internal characteristics like management, employees, and capabilities, and the environmental category takes into account industry, social, and political attributes, including competitors and business partners (Chiu et al., 2017).

To add structure to the technology context of TOE, many studies integrate Rogers' (1995) DOI theory into their conceptual model. The integration of DOI and TOE has been validated as a combined model to explain enterprise-level adoption of innovations (Chiu et al., 2017; Hsu et al., 2006; Piaralal et al., 2015). Particularly, the characteristics of innovation (i.e., relative advantage, compatibility with pre-existing systems, complexity, trialability, potential for reinvention, and observability) have been shown as significant predictors of technology adoption in multiple studies (Rogers, 1995). BT can be leveraged for both data representing the digital world and data representing the physical world. Multiple technology adoption frameworks, such as TOE and DOI, have been combined to address blockchain research studies bridging the digital and physical worlds. Both Wang et al.'s (2010) research on enterprise adoption of RFID in the manufacturing sector and Thomas and Espadanal's (2014) research on cloud computing adoption in the service industry combine TOE and DOI theories. Because new technologies can be complex, combining more than one theoretical model may be appropriate to gain a better understanding of enterprise adoption (Oliveira & Martins, 2011).

TOE-DOI studies across industries, technologies, and organizational characteristics have led to varying results across the five DOI innovation characteristics. One study found that compatibility is the most important factor in technology adoption (Zhu et al., 2006). Wang et al. (2010) found compatibility positively correlated to adoption, while complexity was negatively correlated. Another study found that relative advantage and complexity were inversely correlated to adoption (Low et al. 2011). A study on information and communications technology adoption found all factors except trialability were significant factors in enterprise adoption (Sin Tan et al., 2009). However, a study on cloud computing adoption found that trialability does contribute to the reduction of uncertainties in adoption (Alshamaila et al., 2013).

Annabel et al. (2015) studied enterprise adoption of cloud computing. In their research, organizational context attributes included management support, enterprise size, and technological readiness, which have been validated as significant factors in innovation adoption. Jeyaraj et al. (2006) found top management support as one of the best predictors of enterprise innovation adoption. Lee and Xia (2006) found organization size had a positive correlation to innovation adoption, with several moderating variables. Hameed et al. (2012) studied the correlation between organizational readiness and enterprise innovation adoption and found organizational readiness to be the largest factor.

Because of the core characteristics of BT, as well as the continued regulatory uncertainty, BT exhibits environmental attributes that do not impact other technological innovations. Traditional environmental factors worth exploring are government and regulatory support, business partners, consumer pressure, and competitive pressure. I propose blockchain governance, both on- and off-chain, as a critical consideration to the adoption of BT. Private versus permissioned versus public blockchain governance has implications for sustainability and blockchain development, which should directly influence how enterprises select and adopt a specific BT. Subdimensions influencing enterprise adoption around BT governance include roles, incentives, membership, communication, and decision-making (van Pelt et al., 202).

Debate about theoretical constructs related to enterprise-level adoption of innovations continues in academia. The gap between a generation of new evidence and the translation of the evidence into practice is the single biggest chasm in innovation adoption research today (Allen et al., 2017). This lag is partly due to a lack of understanding and consensus on organizational level factors affecting adoption decisions and implementations, as well as the various characteristics of innovative technologies. One of the major issues in the adoption domain is the inconsistent measurement and lack of information on the reliability and validity of organizational constructs (Allen et al., 2017). Wisdom et al. (2014) found no consistency in measures across studies on innovation adoption. Allen et al. (2017) recommend more mixed methods research in this domain where both qualitative and quantitative methodologies can bring to bear an increased understanding of enterprise-level adoption of innovations.

Models of innovation adoption focus on predictors, moderators, and mediators of adoption. Behavioral intent to adopt is a complex, multi-faceted process and is a distinct research focus in research on adoption within the context of diffusion, dissemination, or sustainability. (Chor et al., 2014). Chor et al. (2014) conducted a meta-analysis of innovation adoption and found 118 measures associated with 27 innovation adoption predictors. The top predictors aligned with the TOE model were found to be complexity, relative advantage, and observability for technological context and organizational size, structure for organization context, and external environment for external context.

Description of the Research Agenda

The research agenda for this dissertation demands a two-step approach to address the research questions. They are both inextricably linked in addressing BT adoption in the context of organizational use cases.

BT represents a unique innovation in the domain of information systems. Technology selection is a critical dimension of technology adoption. Business decision makers seeking to achieve value through BT adoption are met with a nascent industry continuing to explore technological designs. The first paper addresses this challenge for practitioners by creating a taxonomy of blockchain design characteristics as well as a taxonomy of organizational use case characteristics. These two taxonomies serve as axes for a matrix that guides appropriate technological design characteristics required based on the characteristics of any use case. This conceptual paper anchored technological considerations that were explored in the second study.

The second phase of this research involved an empirical, multiple-case study approach of large enterprises which have successfully adopted one or more use cases of BT. Case studies are the most widely used method for qualitative research (Baskarada, 2014) and examine phenomena in-depth within context, especially when boundaries are not clearly evident (Yin, 2017) or for emergent phenomena (Treiblmaier, 2019). Ridder (2017) identified four types of case studies. I employed gaps and holes (Ridder, 2017), which utilizes existing theory to explain how and why enterprises are successful in adopting BT. The sampling method was purposeful sampling, with a focus on large enterprises that successfully adopted public or hybrid protocols. The multiple case study methodology allowed me to uncover commonalities and contextual differences between cases. The results of this research led to a list of success factors across the theoretical dimensions (e.g., technological, organizational, environmental, inter-organizational). These success factors then led to practical recommendations to business practitioners to improve their understanding and decision-making in their blockchain adoption journey.

Blockchain adoption at scale in an enterprise context is nascent. Case study research to build theory on the early adopters of BT creates findings within context making up many complex sets of variables in play intra- and inter-organization. For this reason, I took an interpretivist stance. Interpretivism allows a researcher to have multiple views for a research problem because the research sees the world through the eyes of the participants (Greener, 2008). It is part of subjective epistemology and it takes into account relativist and subjective realities across participants within and between cases. The interpretivist "emphasizes social context and human complexity with regard to how people understand the phenomena" (Rashid et al., 2019, p. 4). An interpretivist view seeks to deeply understand social phenomena while also recognizing the subjectivity of participants because each perceive their own reality. In interpretivist research, participants leverage their own words to relate experiences and beliefs.

Justification of the Research Agenda and Approach

In addressing the research questions, I ultimately seek to influence the adoption of emerging technologies such as BT. There are multiple ways to approach the objective of influencing IS practice depending on the specific context of a research project. Treiblmaier (2019) notes the significant time lag between top academic publications and industry adoption regarding BT. The lengthy review cycle of journals, the complexity of the technology, and poorly understood use cases have created limited research for academia and practitioners alike.

Case studies allow for flexibility and broad applicability required to address previous research challenges in the domain and is well-suited to study nascent phenomena (Treiblmaier, 2019).

The qualitative case study methodology is “an empirical inquiry that investigates a phenomenon in depth within its real-world context, especially when the boundaries between phenomenon and context may not be clearly evident” (Yin, 2017, p. 15). Early adoption often requires deep context across the multiple dimensions provided by theoretical IS adoption frameworks like the TOE model to generate insights that can be defendable.

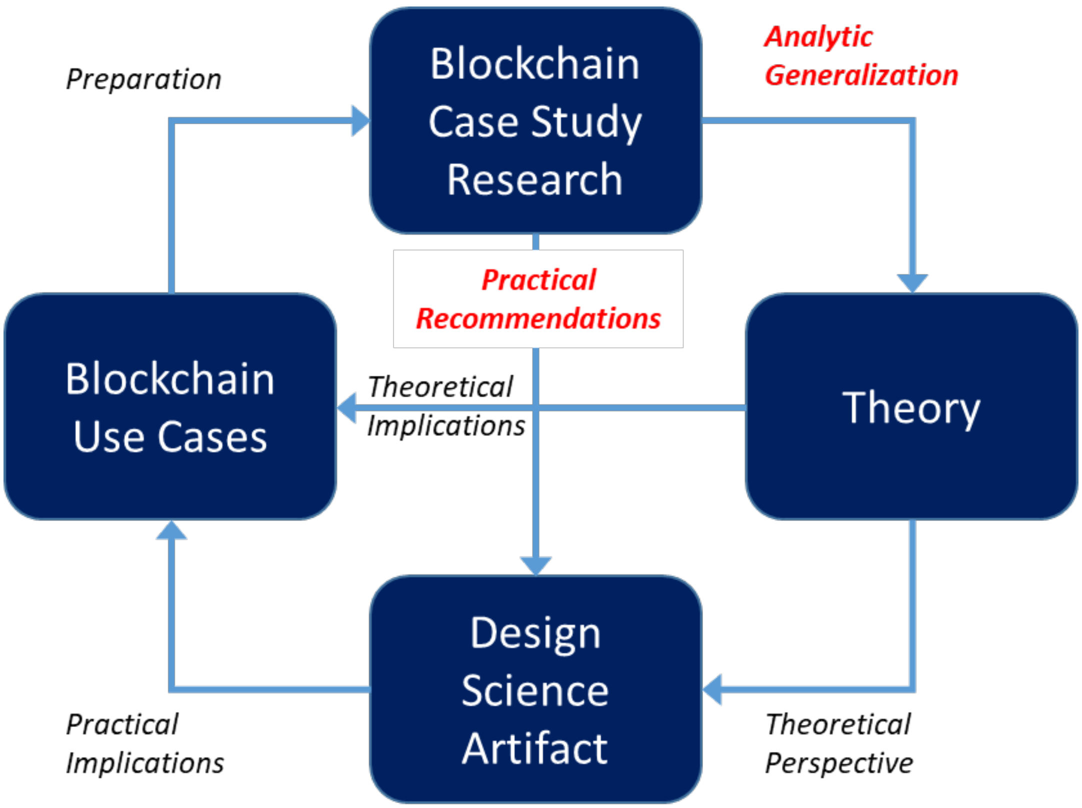
Ridder (2017) presented a comprehensive segmentation of four case study types, each with different strengths and focus. The first is called no theory first, which is leveraged when there are a couple of preliminary variables and constructs, but no assumed relationships. It uses theoretical sampling to analyze and identify emerging constructs within the case or between cases. The second is called gaps and holes, which utilizes existing theory to answer how and why questions about a phenomenon. Purposeful sampling is used to generate pattern matching or analytic generalizations across case studies. The third case study design is called social construction of reality and is generally driven by a researcher’s curiosity about a phenomenon. This type of case study also uses purposeful sampling, but to build categorical aggregation which may help better understand a theoretical issue. The fourth case study type is anomalies, which investigates why a phenomenon cannot be explained by existing theories. It uses theoretical sampling to reconstruct a particular theory based on the case study data and artifacts gathered. Because my motivation included existing technology adoption theory, my research falls under gaps and holes. Existing theory drove initial dimensions for each case study, but the data analysis across cases within my sampling ultimately determined the final constructs for the generalized propositions found in Chapter 4.

The taxonomy matrix artifact was leveraged to frame the case studies. Each case study use case was mapped to the matrix to align the value achieved through the design decisions. Use case characteristics collectively defines use case value through business requirements. These requirements are satisfied through the design characteristics. Each case study's technology adopted was mapped to the technology design characteristics to validate whether the technology selected was appropriate for the use case characteristics, and to determine the value of the use case itself.

Data sources and data collection included interviews with implementation partners or BT representatives and publicly available information. Interviews were semi-structured to allow for deeper dives into specific research areas based on the responses during the interview. In Treiblmaier's (2019) research on case studies for BT, he introduces a framework (Figure 1) to approach case studies depending on the outcome desired. I sought to create practical recommendations in the form of a summary of action principles early adopters of BT leveraged in their journey to continue the use of BT. Action principles seek to arm IS practitioners seeking to adopt a technology with key success factors and barriers overcome by experienced early adopters of that technology (Lacity et al., 2021).

Figure 1

A Framework for Blockchain Case Study Research



Action principles research seeks to create a set of action principles that answer the following questions (Lacity et al., 2021):

- Robustness: What is the same?
- Distinctiveness: What is unique?
- Provocativeness: What is surprising?

Enterprises seeking to design and implement BT applications should seek out principles that guide their journey based on lessons learned from innovators and early adopters to improve chances of successful adoption or fast failure. Lacity (2018) states that, at a minimum, action principle research should seek to understand robustness and distinctiveness. A benefit of the qualitative nature of the action principle methodology is to potentially develop provocative principles. Because BT introduces new dimensions of managerial decision-making during the solution design and implementation (e.g., on- and off-chain governance embeddedness), action principles in this study sought to identify principles in areas where BT is unique compared to other technologies. Because I am not a technical IS architect and my background is light on deep technical expertise in traditional IS capabilities (e.g., architecture, software design), the research methodology offered me the ability to engage with various constituents of an organization to obtain data. Unlike design science and action research, which require high technical expertise in BT, action principles research requires low technical expertise, high interpersonal skills, and medium business or consulting expertise. My interpersonal skills, my deep business acumen, and a decade of consulting experience enabled a good fit for action principles methodology.

CHAPTER 3: A TAXONOMY MATRIX OF ENTERPRISE BLOCKCHAIN TECHNOLOGY DESIGN AND USE CASES

Introduction

In recent years, BT has emerged as a unique innovation in the realm of information systems, offering decentralized features that compel organizations to rethink traditional approaches to conducting business and managing data. As BT continues to expand and innovate, enterprises are faced with the challenge of navigating this nascent landscape and identifying the most appropriate blockchain designs for their specific use cases. This challenge is exacerbated by novel considerations stemming from BT adoption, such as enterprises' roles as governance nodes that validate data and the regulatory uncertainties associated with native cryptocurrencies. Moreover, businesses must also persuade network partners to explore and adopt BT, necessitating a structured and strategic approach to technology selection and implementation. In recognition of these complexities, the present study aims to develop a comprehensive framework that guides enterprises through the intricate process of evaluating various BT designs and understanding their potential applications.

The first part of this paper proposes a taxonomy of blockchain design characteristics, focusing on features such as permission level, data access, transaction consensus, modularity, scalability, interoperability, centralization, and anonymity. This taxonomy builds on previous research (Walsh et al., 2016) to offer a more sophisticated and structured approach to understand the diverse range of BT options available in the market. Additionally, this study develops a taxonomy of organizational use case characteristics that enables businesses to determine the most appropriate BT solutions for their specific contexts.

These two taxonomies form the basis for a matrix designed to guide appropriate technological design selection for any given use case. By providing a systematic framework to evaluate and match blockchain designs with specific use cases, enterprises can lower the risk of technical failure and increase the chances of successful BT adoption. This strategic approach is particularly valuable for businesses exploring BT as an ecosystem technology, as it can help accelerate the process of persuading network partners to adopt and participate in blockchain initiatives.

Building upon existing research that highlights the trial-and-error nature of blockchain experimentation (Labazova et al., 2019) and the complexity of BT adoption (Xu et al., 2017), this study seeks to make a substantial contribution to the growing body of knowledge on blockchain implementation within enterprises. The proposed framework not only facilitates the technology selection process for practitioners but also lays the foundation for applying these insights to future BT innovations. By mitigating the risks and potential losses associated with blockchain adoption, the ultimate goal of this research is to enable organizations to harness the transformative potential of this emerging technology.

Related Research

Taxonomies are forms of classification, along with typologies, ontologies, and frameworks. Despite being often used interchangeably, each aims at slightly different outcomes. Classifications are the fundamental mechanism to organize knowledge (Wand et al., 1995). A classification system can be visualized as a set of boxes that things can be put into to do some kind of work (Bowker & Star, 1999). Ontology is the study of what is through questioning the types of structures, events, and processes of any area of reality (Smith, 2008). Although ontologies can sometimes function like taxonomies (Wand & Weber, 2004), Dogac et al. (2002)

note they are distinct artifacts. Typology is a system of conceptually derived groupings, usually multi-dimensional and more complex than classification systems (Nickerson et al., 2013). The term framework is a general term, like classification, which is used to organize objects.

Taxonomies are important to help researchers and practitioners understand and analyze complex domains (Nickerson et al., 2013). Taxonomies create structure and enterprise to knowledge in a field, resulting in the ability to study relationships between concepts and develop hypotheses (Glass & Vessey, 1995). This ability becomes increasingly important in nascent, complex domains such as BT, where design and design selection decisions are often made without substantial real-world adoption. Taxonomies support the ability to understand the science behind design principles of observed artifacts (Williams et al., 2008). Iivari et al. (1998) noted taxonomies are forms of conceptual knowledge in design science and the goal of taxonomies aim to "identify essences in the research territory and their relationships" (p. 46).

Taxonomy development is a complex process (Nickerson et al., 2013). Various disciplines provide guidance to researchers seeking to develop taxonomies in nascent domains. Biology, for instance, uses taxonomies such as the Linnaean taxonomy to organize living things based on a predefined hierarchy of categories. Each organism is placed in the taxonomy based on where it fits at each level of the hierarchy. Phenetics and cladistics are two other methods of organizing with taxonomies. Phenetics involves classifying based on common characteristics and cladistics examines evolutionary relationships between organisms (Eldridge & Cracraft, 1980).

Bailey (1994) suggests a three-level approach to taxonomy development, which includes conceptual, empirical, and indicator levels. The resulting artifact should have a set of dimensions that consist of mutually exclusive and collectively exhaustive characteristics, and every object has precisely one characteristic in every dimension (Nickerson et al., 2013).

Nickerson et al. (2013) attempted to develop a methodology for taxonomy development in IS, noting existing research has not adequately addressed taxonomy development by using an ad hoc approach. The result of his research outlined a taxonomy development method for IS that incorporates both an empirical-to-conceptual (induction) and a conceptual-to-empirical (deduction) approach to fulfill ending conditions set out by a researcher. These ending conditions can be either objective or subjective and are met through multiple iterations of the methodological process. Omair and Alturki (2020a) note that the rigidity in Nickerson's methodology can limit taxonomy development because it does not "provide a technique that supports creativity and can deal with surprising derived results, which can be handled by adopting abduction as a form of logical reasoning" (p. 536). They also point out that abduction can be a creative approach to design artifacts, such as a taxonomy, when little knowledge exists.

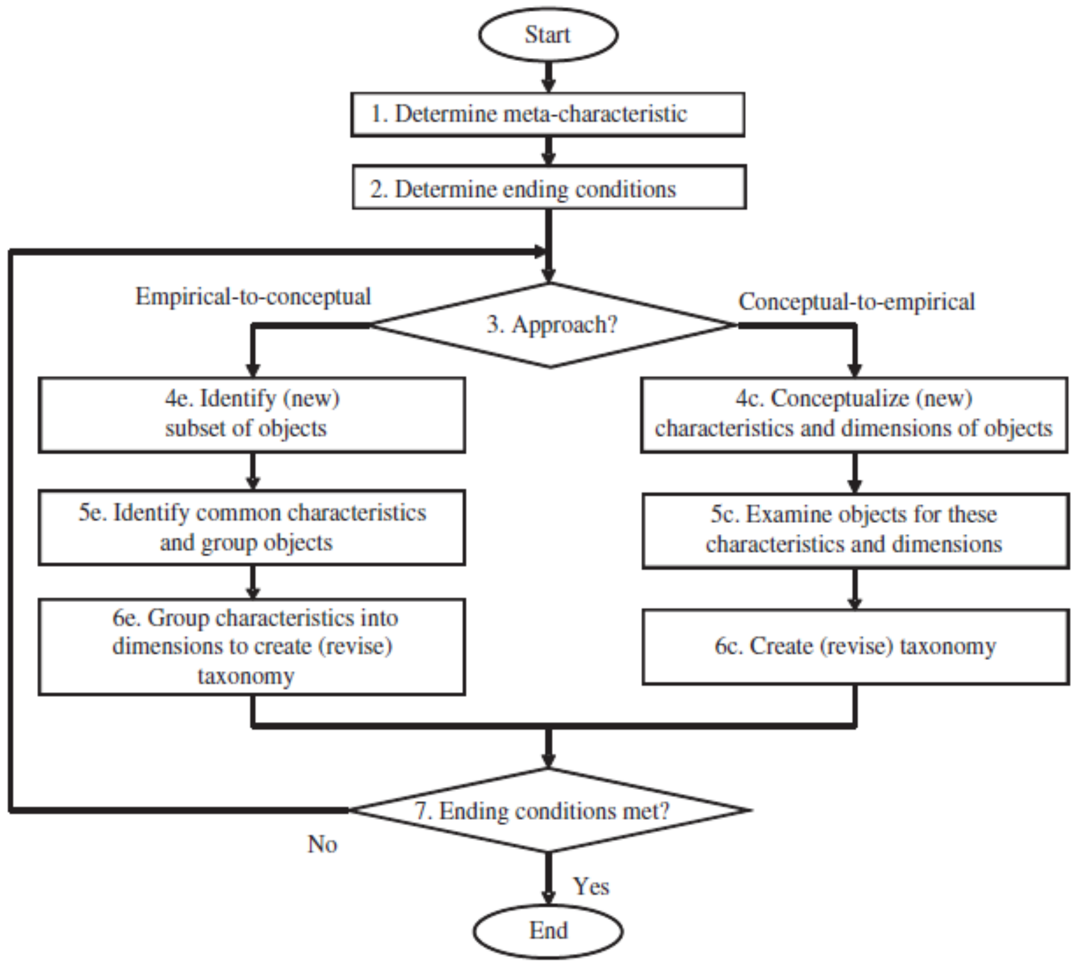
A goal of taxonomy development is like design science research, in which design is a search process and includes a generate and test cycle. Omair and Alturki (2020b) suggest that an optimal taxonomy is intractable, therefore any methodology a researcher leverages should include different strategies iteratively to reach a useful taxonomy. Their approach extends Nickerson's process by embedding abduction as an essential addition for domains in which a researcher may be handicapped in knowledge. These handicaps can include limited empirical data, restricted knowledge access, time or location obstacles, or data that cannot support the derived results.

A useful taxonomy has several qualitative attributes that make it valuable (Nickerson et al., 2013). First, it is concise. A taxonomy should contain a limited number of dimensions and characteristics within each dimension. Attempting to create a taxonomy that includes an exhaustive list of dimensions or characteristics may exceed the cognitive load of the researcher and thus be difficult to comprehend and apply (Bailey, 1994). Second, it should be robust. A taxonomy should have the number of dimensions and characteristics required to clearly differentiate between objects. A useful taxonomy consists of groups that are distinct from one another, yet members within a group are as alike as possible. Third, a taxonomy should be comprehensive. While this attribute may seem to contradict the concise attribute, the key is that a taxonomy allows the researcher to classify all known objects within the domain under consideration (Nickerson et al., 2013). Fourth, taxonomies should be extendible. Particularly in a nascent technological domain such as BT, the ability to include additional dimensions or new characteristics within a dimension when new types of objects are developed is important to ensure the taxonomy becomes a living, not static, reference of the current state. Finally, taxonomies should be explanatory. The dimensions and characteristics should not describe every detail of the reference objects, but rather useful explanations of the nature of the objects. Explanatory taxonomies allow somebody who knows the characteristics of an object to clearly find an identifiable place in the taxonomy which represents those characteristics. The nascent domain of BT requires a particular focus on extendibility to ensure the evolution of technological design and use case development are able to be included through iteration.

Nickerson et al. (2013) proposed a methodology for taxonomy development (Figure 2) in IS technology based on a systematic review of taxonomy development in other disciplines resulting in desirable qualities. IS taxonomy development is largely ad hoc and over 40% of the papers Nickerson et al. (2013) surveyed did not identify a taxonomy development approach.

Figure 2

The Taxonomy Development Method

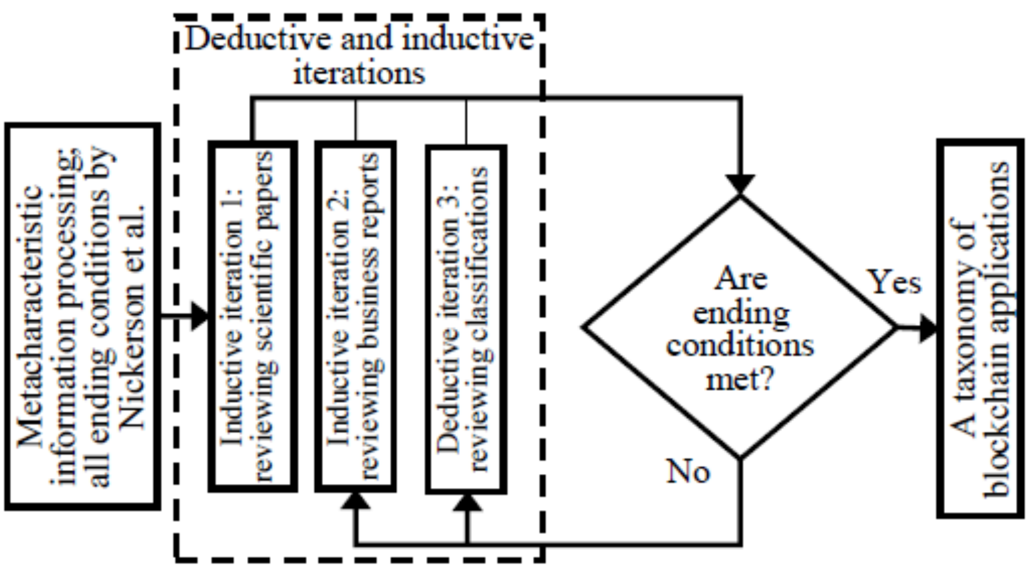


The first step to developing a taxonomy is to identify meta-characteristics that are based on the purpose of the taxonomy. These meta-characteristics should support the intended use of the taxonomy. Next, the ending conditions are established by defining objective and subjective outcomes. Ending conditions are defined as a taxonomy state achieved to terminate further iterations. Once all ending conditions are identified, the researcher determines whether an empirical-to-conceptual or conceptual-to-empirical approach is most appropriate depending on the availability of data about objects under study. With limited initial data, a conceptual-to-empirical approach is best. With significant data, even with limited domain knowledge, pursuing an empirical-to-conceptual path is optimal. After several iterations, identified ending conditions will be met and the resulting taxonomy needs to be evaluated for usefulness in the context of the stated objectives of the research (Nickerson el. al., 2013).

Labazova et al. (2019) leveraged Nickerson's approach to develop a taxonomy of blockchain applications. The method (Figure 3) uses both inductive and deductive iterations. I propose a similar approach for this research, by developing initial dimensions and characteristics from the rigor of scientific literature, then moving towards practical relevance through business reports of blockchain protocols and use cases in real-world environments. Finally, the ability to deductively review classifications to enhance taxonomic dimensions and characteristics through legitimately proposed solutions will be a critical step to fulfilling ending conditions.

Figure 3

Taxonomy Approach for Blockchain Applications



Research Approach, Taxonomy Development

The objective of this study is to create a taxonomy matrix with one axis blockchain design characteristics and the other axis of use case characteristics. For the meta-characteristics, I selected the value propositions, or key driving principles (Tasca & Tessone, 2019), of BT (i.e., consensus, transparency, security). The variation of design considerations of these meta-characteristics is central to the optionality of a practitioner's decision-making process. Technology selection is driven by the suitability of the technology to satisfy business requirements, which are the implicit descriptions of the value an enterprise seeks to generate from the implementation of said technology.

Taxonomy development in social sciences has been described as taking an empirical and inductive approach (Bailey, 1994). As opposed to a typology, which is conceptual and deductive, Bailey (1994) claims taxonomies determine the deviation from the ideal type based on the empirical realities of the world. In this approach, researchers develop a typology based on a theoretical foundation. One method, called substruction, is to add dimensions until a satisfactory enterprise of objects is complete. Another method, called reduction, involves conceptualizing a vast number of dimensions, then eliminating some until there is sufficient parsimony. In this study, the approach used is substruction to develop a taxonomy that is sufficiently comprehensive for practical application.

The aim of taxonomy development is to create useful taxonomies, not perfect or correct ones, as any claim could not be defended (Nickerson et al., 2013). Particularly, in an emerging technological domain, design considerations and use cases could change over time, so the goal of creating a taxonomy is to search for optimal classification based on the current knowledge (Nickerson et al., 2013). It is crucial to meet a set of objective and subjective conditions (Table

1) that ensure the practicality and effectiveness of the resulting framework. Meeting these conditions ensures a robust, reliable foundation for businesses to make informed decisions while tackling the complexities of the BT landscape.

Table 1

Taxonomy Ending Conditions

Ending Condition Type	Ending Condition Description	Explanation of Satisfaction
Objective Conditions	All available taxonomy objects must be studied	Comprehensive analysis of all relevant characteristics
	No changes in dimensions or characteristic after the last dimension	Consistent taxonomy without alterations upon completion
	Every characteristic for each dimension should have at least one object	Meaningful connections ensured
	All dimensions and characteristics within a dimension are unique	No redundancy in the taxonomy
Subjective Conditions	Concise	Clear, compact representation for easy understanding.
	Robust	Reliable foundation for compatibility analysis.
	Comprehensive	Covers spectrum of enterprise blockchain applications.
	Extendible	Accommodates future advancements seamlessly.
	Explanatory	Guides decision-making with valuable insights.

Objective conditions emphasize thorough analysis and comprehensive analysis of all pertinent characteristics within a taxonomy. Stability is achieved when dimensions and characteristics remain unchanged after the final dimension is established. It is essential that for every characteristic within each dimension, at least one object is connected to create meaningful and relevant relationships. Additionally, a taxonomy must avoid redundancy by maintaining unique dimensions and characteristics. Subjective conditions focus on qualities that contribute to the overall applicability and usefulness of a taxonomy in real-world scenarios. A concise and clear representation is key for practitioners to understand and leverage for implementation. Robustness in the framework ensures dependability when it comes to compatibility analysis and covering a wide range of enterprise blockchain applications offers versatility. Equally important is a taxonomy's extendibility, allowing it to accommodate future advancements seamlessly and remain relevant in the evolving BT domain. Lastly, a taxonomy should provide explanatory insights to guide businesses through the BT adoption journey. Satisfying these conditions can result in a valuable tool set for organizations pursuing the transformative potential of BT.

To generate the comprehensive taxonomies of enterprise blockchain design and use case characteristics, I undertook a systematic data analysis process. This process consisted of data collection, examination, and synthesis, applying both qualitative and quantitative methods to ensure a robust, well-rounded analysis. The data for this study was sourced from a variety of platforms to ensure broad coverage of the rapidly evolving blockchain space. Each of the individual taxonomies was developed over three iterations. Because in each case, physical implementation and theoretical knowledge already exist, both approaches of taxonomy development (i.e., conceptual → empirical, empirical → conceptual) can be used.

The first iteration was performed through a literature review of the domain. In this iteration, I followed a logical process based on a firm theoretical foundation, which included a review of the existing taxonomies highlighted in published papers. I searched for articles with the search string “blockchain OR distributed ledger” as well as “taxonomy” in the title and abstract, covering all publications by time period and type. The search returned 282 papers. After screening titles and abstracts, I coded 129 remaining relevant articles. The analysis process involved thematic analysis. This approach involves identifying patterns, themes, and categories within the data. This was achieved through a process of coding, which assigns labels or tags to sections of data that corresponded to specific themes or concepts. The iteration created detailed information of design and use cases included in literature but lacked comprehensiveness due to the evolving nature of an emerging technology like blockchain.

In the second iteration, I reviewed business reviews, white papers, and other publicly available artifacts to generate additional dimensions and components. These artifacts were issued by governments, consulting firms, and third-party blockchain news agencies. The third iteration involved reviewing the classifications and taking a deductive approach to ensure ending criteria (e.g., mutual exclusivity) were satisfied. Refinements were made to both classifications and attributes generated in the first two iterations, as well as adding additional attributes to ensure comprehensiveness for enterprise blockchain design and use case characteristics. The iterative process of open coding, thematic analysis, and continuous refinement led to the development of two comprehensive taxonomies that encapsulate the design characteristics of enterprise BT and the characteristics of its use cases. These taxonomies enabled a comprehensive overview of the current landscape of enterprise BT and its use cases, offering a valuable tool for both researchers and practitioners in the field. For blockchain design characteristics, I identified 11 dimensions coinciding with 59 components. For use case characteristics, I identified six dimensions coinciding with 36 components.

Analysis and Results: Taxonomy to Match BT with Use Cases

The taxonomy developed on BT design characteristics refer to the essential elements and attributes that define the structure, behavior, and properties of blockchain systems when implemented in various business contexts. The specific combination of design characteristics is highly dependent on the targeted use case, business requirements, and desired outcomes. A comprehensive evaluation of these characteristics is critical for enterprises seeking to adopt BT, as it allows for tailoring the system to meet the unique demands of business operations while ensuring regulatory compliance, risk management, and efficient resource allocation. An understanding of design characteristics serves to prepare for potential challenges, such as performance bottlenecks, privacy concerns, and interoperability issues and facilitates strategic decision-making regarding the adoption and implementation of BT.

Enterprise BT use case characteristics can be defined as the specific aspects and properties that are relevant to the successful integration of blockchain-based solutions within the organizational context. These characteristics encompass dimensions such as application type, value proposition, implementation complexity, ecosystem, regulatory considerations, and integration with existing systems. Identifying these characteristics for any given use case is essential for businesses to determine the feasibility, scope, and potential impact of employing BT in various enterprise scenarios. Analysis of use case characteristics helps to comprehend potential benefits, challenges, and trade-offs associated with adopting BT and empowers stakeholders to make informed strategic decisions about the design, development, and deployment of BT solutions that cater to their specific requirements while addressing potential concerns such as data privacy, security, performance, and regulatory compliance.

Taxonomy of Enterprise Blockchain Technology Characteristics

The resulting taxonomy of enterprise blockchain design characteristics serves as a foundation to understand the diverse ecosystem of blockchain technologies suited for enterprise use. The taxonomy categorizes key technical dimensions of blockchain solutions, encompassing network types, consensus mechanisms, data privacy and confidentiality, smart contracts, scalability, interoperability, and various methods to ensure security and compliance.

Preliminary insights from this taxonomy highlight the versatility and adaptability of blockchain technologies, catering to a wide range of use cases and requirements across industries. The design characteristics reveal that trade-offs exist among various aspects, such as decentralization, privacy, and performance. The taxonomy also illustrates the importance of balancing desired features, such as transparency, scalability, security, and regulatory compliance, in implementing successful enterprise blockchain solutions. The following section covers each taxonomy component to illustrate the diversity and potential applicability of blockchain technologies in enterprise use cases.

- Network Type

1. Public: A public blockchain network is an open, decentralized platform where anyone can participate, read, and write transactions. It operates on a consensus mechanism to validate transactions and maintain the integrity of the network. Examples: Bitcoin and Ethereum.
2. Permissioned Public: A permissioned public blockchain network is a semi-decentralized platform where participants must be granted permission to read, write, or validate transactions. This type of network provides more control over the participants while maintaining some level of openness. Examples: Ripple and Stellar.
3. Consortium: A consortium blockchain network is a partially decentralized platform governed by a group of pre-selected enterprises or entities. These enterprises share the responsibility of validating transactions and maintaining the network's integrity. Examples: R3 Corda and Quorum.
4. Private: A private blockchain network is a centralized platform where access, participation, and control are restricted to a single enterprise or a limited set of

entities. Private blockchains are typically used for internal purposes and offer higher levels of privacy, security, and control. Examples: Hyperledger Fabric and MultiChain.

- Consensus Mechanism
    1. Proof of Work (PoW): PoW is a consensus mechanism where participants, called miners, compete to solve complex mathematical problems to validate transactions and add new blocks to the blockchain. The first miner to solve the problem is rewarded with newly created cryptocurrency. Example: Bitcoin.
    2. Proof of Stake (PoS): PoS is a consensus mechanism where participants, called validators, lock up a portion of their cryptocurrency holdings as a stake. Validators are chosen to create new blocks and validate transactions based on their stake and other factors, such as the age of their holdings. Examples: Ethereum and Cardano.
    3. Proof of Authority (PoA): PoA is a consensus mechanism where a limited number of trusted entities, called authorities, are responsible for validating transactions and creating new blocks. PoA offers faster and more energy-efficient transaction validation compared to PoW and PoS. Examples: VeChain and POA Network.
    4. Delegated Proof of Stake (DPoS): DPoS is a variation of PoS where token holders vote for a select group of delegates, who are responsible for validating transactions and maintaining the network. DPoS aims to provide a more democratic and scalable consensus mechanism. Examples: EOS and Lisk.
    5. Practical Byzantine Fault Tolerance (PBFT): PBFT is a consensus mechanism designed to tolerate a certain number of malicious or faulty nodes in the network. It relies on a voting process among nodes to validate transactions and reach an

agreement, providing high levels of security and fault tolerance. Examples: Hyperledger Fabric and Tendermint.

6. Federated Byzantine Agreement (FBA): FBA is a consensus mechanism used in consortium and permissioned public blockchain networks. It operates through a set of trusted nodes, called quorums, that validate transactions and maintain the network's integrity. FBA provides a balance between decentralization and efficiency. Examples: Stellar and Ripple.

- Data Privacy & Confidentiality

1. Public Data (Openly accessible on the blockchain): Public data refers to information stored on a public blockchain that can be accessed, read, and verified by anyone. This type of data promotes transparency and auditability. Examples: Bitcoin and Ethereum transaction data.
2. Encrypted Data (Accessible only to authorized parties): Encrypted data refers to information stored on a blockchain in a secure, encrypted format. Access to this data is restricted to authorized parties who possess the necessary decryption keys. Examples: Monero and Zcash.
3. Zero-Knowledge Proofs: Zero-knowledge proofs are cryptographic techniques that allow one party to prove the validity of a statement without revealing any information about the statement itself. This enables privacy-preserving transactions and data sharing on a blockchain. Examples: Polygon zkEVM and zk-SNARKs in Ethereum.
4. Confidential Transactions: Confidential transactions are a privacy-preserving technique that conceals transaction details, such as sender, receiver, and amount,

while maintaining the integrity and security of the transaction. Examples: Confidential Assets in Liquid Network and Mimblewimble protocol.

- Smart Contracts

1. Smart Contract Language Capabilities: This refers to the ability to use multiple coding languages in smart contract development. Examples: Ethereum and Hyperledger Fabric
2. Turing Complete: A Turing complete smart contract language is capable of expressing any computable algorithm, allowing for the creation of complex and versatile smart contracts. Examples: Solidity in Ethereum.
3. Non-Turing Complete: A non-Turing complete smart contract language is limited in its computational capabilities, focusing on specific use cases and providing a more secure and efficient environment for smart contracts. Example: Bitcoin Script.
4. Off-chain Execution: Off-chain execution refers to the processing of smart contract logic outside the main blockchain, reducing the computational load on the network and improving scalability. Examples: Ethereum's Layer 2 solutions and Chainlink oracles.
5. Oracles: data feeds that provide external, real-world information to smart contracts on the blockchain. They act as a bridge between the blockchain and the external world, pulling in data that isn't natively available within the blockchain. This data could range from price information to election results to weather reports, among other examples, and is used to trigger the execution of smart contracts when certain conditions are met. Examples: Chainlink and Band Protocol

6. Privacy-Preserving Smart Contracts: Privacy-preserving smart contracts enable the execution of smart contract logic while maintaining the confidentiality of sensitive data involved in the contract. Examples: Enigma protocol and Aztec protocol.

- Scalability & Performance

1. Layer 1 Scaling - Sharding: Sharding is a Layer 1 scaling technique that divides the blockchain network into smaller, more manageable segments, allowing transactions to be processed concurrently and improving overall network performance. Examples: Ethereum 2.0 and Zilliqa.
2. Layer 2 Scaling - State Channels: State channels are off-chain communication channels that enable participants to transact and interact directly, bypassing the main blockchain. This reduces transaction costs and improves scalability. Examples: Lightning Network for Bitcoin and Raiden Network for Ethereum.
3. Layer 2 Scaling - Plasma Chains: Plasma chains are off-chain scaling solutions that create child chains connected to the main blockchain, enabling faster and more efficient transaction processing. Examples: OMG Network and Matic Network.
4. Layer 2 Scaling - Optimistic Rollups: Work on the principle of optimism, meaning they assume that all transactions are valid by default. They allow for the execution of smart contracts with almost similar security guarantees to the Ethereum mainnet. Transactions are executed and posted on-chain, but the computation and state storage are conducted off-chain. If a transaction is fraudulent, it is up to the network's participants to identify it and submit proof of fraud.
5. Layer 2 Scaling – ZK-Rollups: Bundle multiple transfers into a single transaction using zero-knowledge proofs, a cryptographic method that allows one party to prove

to another that a statement is true, without revealing any specific information beyond the validity of the statement itself allowing transactions to be validated before being added to the blockchain.

- Interoperability
  1. Cross-Platform Compatibility: Cross-platform compatibility refers to the ability of different blockchain networks to interact, exchange information, and collaborate seamlessly.
  2. Cross-Chain Communication: Cross-chain communication enables different blockchain networks to interact and exchange data, assets, and transactions, promoting interoperability and cross-chain functionality. The ability of different blockchain protocols to interact and transact with one another. This is an important feature as it allows for asset transfers, data sharing, and functionality across multiple distinct blockchain systems. For instance, if Blockchain A and Blockchain B can communicate, you might be able to move a token from A to B seamlessly. Examples: Polkadot and Cosmos.
  3. Token & Asset Bridges: Token and asset bridges facilitate the transfer of assets and data between different blockchain networks, promoting interoperability and cross-chain functionality. Examples: Ethereum and Binance Smart Chain bridge.
  4. Sidechains & Parachains: Sidechains and parachains are auxiliary blockchain networks connected to a main blockchain, enabling the transfer of assets and data between networks and improving interoperability. Examples: Liquid Network for Bitcoin and Polkadot's parachains.

- Identity & Access Management
    1. Decentralized Identifiers (DIDs): Decentralized identifiers are a type of digital identity that is self-sovereign, enabling users to own, control, and manage their identities without relying on a centralized authority. Examples: Microsoft's ION and Sovrin.
    2. Role-Based Access Control: Role-based access control is an identity and access management technique where access permissions are granted based on predefined roles assigned to users. Examples: Role-based access control in Hyperledger Fabric.
    3. Attribute-Based Access Control: Attribute-based access control is an identity and access management technique where access permissions are granted based on user attributes, such as job title, department, or seniority. Examples: Attribute-based access control in Hyperledger Fabric.
- Governance & Compliance
    1. On-chain Governance: This refers to the decision-making processes that are embedded within the blockchain itself. Protocols, rules, and decision-making processes are encoded into the blockchain, and decisions are enforced automatically. Examples of protocols that feature on-chain governance include Tezos and Polkadot.
    2. Off-chain Governance: This refers to decision-making processes that occur outside of the blockchain's protocol. This may involve decisions made by developers, a foundation, or miners, and they may be informal and based on social or political mechanisms. Examples include Bitcoin and Ethereum.
    3. Regulatory Compliance: Some blockchain protocols have features that allow entities using the blockchain to comply with relevant laws and regulations. This may include

features related to security, privacy, financial regulations, etc. An example is Corda, a blockchain platform designed for the financial industry that has built-in features to facilitate compliance with financial regulations.

4. KYC/AML: Some blockchain protocols have integrated Know Your Customer (KYC) and Anti-Money Laundering (AML) features to help entities using the blockchain comply with these regulations. This may involve identity verification, transaction monitoring, etc. An example is R3's Corda which is designed with financial institutions in mind and supports KYC/AML compliance.
5. Auditing/Monitoring: This refers to the ability of a blockchain protocol to provide transparent, verifiable records that can be used for auditing and monitoring purposes. Almost all blockchains have inherent auditing and monitoring capabilities due to their transparent and immutable nature. An example of a protocol specifically designed for auditability is Hyperledger Fabric, which has features like channel and private data collections to facilitate the sharing of data with auditors.
6. Personal Data (e.g., GDPR, HIPAA): Some blockchains have features designed to help entities using the blockchain comply with personal data protection laws like the General Data Protection Regulation (GDPR) in the European Union or the Health Insurance Portability and Accountability Act (HIPAA) in the United States. This can be a challenging area for blockchains due to issues around the right to be forgotten and the immutability of blockchains. Examples of projects working on this include Oasis Labs with their privacy-preserving blockchain platform, and Hyperledger Indy, a distributed ledger built specifically for decentralized identity with privacy considerations.

- Asset & Tokenization
    1. Native Asset: A native asset is a digital asset or cryptocurrency that is native to a particular blockchain network and serves as its primary medium of exchange, store of value, or unit of account. Examples: Bitcoin and Ether.
    2. Tokenization: Tokenization refers to the process of representing real-world assets, such as stocks, bonds, or real estate, as digital tokens on a blockchain network. This enables fractional ownership, streamlined asset transfer, and improved liquidity. Examples: Security tokens and stablecoins.
    3. Fungible Tokens (ERC-20): Fungible tokens are digital tokens with equal value and interchangeable properties, making them suitable for representing standardized assets, such as currencies or utility tokens. ERC-20 is a widely adopted token standard on the Ethereum blockchain. Examples: Tether and Chainlink.
    4. Non-Fungible Tokens, NFTs (ERC-721): NFTs are digital tokens with unique properties and distinct values, making them suitable for representing one-of-a-kind assets, such as digital art, collectibles, or real estate. ERC-721 is a popular token standard for creating NFTs on the Ethereum blockchain. Examples: CryptoKitties and NBA Top Shot.
    5. Security Tokens (ERC-1400): Security tokens are digital tokens that represent ownership in real-world assets, such as stocks, bonds, or real estate, and are subject to securities regulations. ERC-1400 is a token standard on the Ethereum blockchain designed for creating and managing security tokens. Examples: tZERO and Polymath.
    6. Central Bank Digital Currency (CBDC): A central bank digital currency is a digital form of a country's fiat currency, issued and regulated by the central bank. CBDCs

aim to provide a digital alternative to physical cash, enabling faster and more efficient payment systems. Examples: China's Digital Yuan and Sweden's e-Krona.

- Data Storage & Management
    1. Data Structures: This refers to the way data is structured, organized, and stored in a blockchain protocol. For example, Bitcoin uses a UTXO (Unspent Transaction Output) model and Ethereum uses an account-based model.
    2. Merkle Patricia Trees: This is a type of data structure used to store data in an efficient and secure manner. Ethereum uses Merkle Patricia Trees to store transaction data and contract state.
    3. On-chain Storage: This refers to data stored directly on the blockchain. All transactions and smart contract executions in blockchains like Bitcoin and Ethereum are examples of on-chain storage.
    4. Off-chain Storage (e.g., Distributed Hash Table): Refers to data stored outside of the blockchain. This is typically used to improve scalability and efficiency. OrbitDB is an example of a decentralized database that uses a distributed hash table and operates on top of the InterPlanetary File System (IPFS).
    5. Data Versioning & Timestamping: This feature allows for the recording of different versions of data and the specific times they were recorded. Gitcoin, a blockchain-based platform for collaborative projects, uses data versioning and timestamping for its operations.
    6. Decentralized Storage Solutions (e.g., IPFS, Filecoin): These are protocols that provide decentralized data storage, where data is not stored by a central entity but is instead distributed across many nodes. Examples include IPFS and Filecoin.

7. Data Formats and Serialization (e.g., JSON, protobuf): This refers to how data is formatted and serialized for storage and transmission. Ethereum uses Recursive Length Prefix (RLP) for data serialization, while other projects like Protocol Buffers (protobuf) from Google are also used in various blockchain projects.
8. Data Exchange Protocols (e.g., GraphQL, REST): This refers to how data is exchanged between different systems. The Graph is a protocol for building decentralized applications (dApps) quickly on Ethereum and IPFS using GraphQL.
9. Cross-chain Communication (e.g., atomic swaps, bridges): This allows for the transfer of data or value between different blockchains. Cosmos and Polkadot are examples of protocols that facilitate cross-chain communication.

- Security

1. Cryptography: Cryptography refers to the use of mathematical techniques and algorithms to secure data and communications in a blockchain network. Examples include cryptographic hashing, digital signatures, and public-key cryptography.
2. Multi-Signature Transactions: Multi-signature transactions are a security feature that requires multiple parties to sign and approve a transaction before it can be executed, providing an additional layer of security and preventing unauthorized access. Examples: Multi-signature wallets in Bitcoin and Ethereum.
3. Hardware Security Modules (HSM): Hardware security modules are specialized, tamper-resistant devices designed to securely generate, store, and manage cryptographic keys, providing an additional layer of security for blockchain networks and applications. Examples: Ledger Nano and Trezor hardware wallets.

4. Secure Multi-Party Computation (SMPC): SMPC allows multiple parties to jointly compute a function over their inputs while keeping those inputs private. This is particularly useful in scenarios where enterprises need to collaborate on sensitive data without revealing their individual data. Example: Collaborative data analysis between multiple financial institutions. They can use SMPC to jointly compute risk metrics or detect fraudulent activities without revealing sensitive customer data to each other.
5. Key Management Systems (KMS): KMS is essential for managing cryptographic keys used for encryption, decryption, and signing operations. Proper key management ensures that keys are securely stored, rotated, and revoked when needed. Example: A healthcare consortium using blockchain to share patient records among hospitals and clinics. The consortium can use KMS to manage the cryptographic keys required for secure communication between participants and ensure only authorized parties can access and modify the data.
6. Vulnerability & Penetration Testing: Regular vulnerability assessment and penetration testing help identify potential security weaknesses in a blockchain system and ensure that it remains secure against attacks. Example: An enterprise deploying a permissioned blockchain for managing its supply chain. Conducting regular vulnerability and penetration testing can help the enterprise detect and mitigate any potential security risks, ensuring the integrity of the supply chain data and protecting against unauthorized access.

Taxonomy of Enterprise Use Case Characteristics

Use case characteristics are the distinguishing features or attributes of a use case. These characteristics encompass a wide range of factors, including the nature of the problem being addressed, the stakeholders involved, the technology being used, the benefits and drawbacks of the solution, and the overall feasibility of the use case.

The taxonomy of enterprise BT use case characteristics developed provides a structured analysis of the diverse aspects of blockchain implementations across various industries and applications. These characteristics were selected to cover a broad range of criteria, encompassing the application type, value proposition, implementation complexity, ecosystem, regulatory considerations, and integration with existing systems. Categorizing the use cases under these characteristics enables a methodological assessment of the potential advantages, challenges, and nuances associated with each use case. The taxonomy structure can enable enterprises to make well-informed decisions when exploring and implementing BTs in their operations.

- Application Type
    1. Data Management: The use of BT for secure storage, retrieval, and sharing of data across multiple parties.
    2. Asset Tracking and Ownership: The implementation of BT for verifying and maintaining records of asset ownership, transfer, and history.
    3. Contract Automation Self-executing, programmable contracts with the terms of the agreement directly written into code, enabling automation and decentralization of contractual processes.
    4. Decentralized Applications (DApps): Applications built on top of a blockchain platform that leverage its decentralized nature and smart contract capabilities.
    5. Identity Management: The use of BT for secure and efficient management of digital identities, including authentication, authorization, and access control.

6. Payment Systems: The implementation of BT for facilitating digital payments, remittances, and transfers without intermediaries.
7. Communication: The application of BT for secure, decentralized, and tamper-proof communication between parties.

- Value Proposition

1. Transparency: A clear, open, and auditable record of transactions and data. Achieved through a shared, distributed ledger where all participants have access to a consistent view of the data, fostering trust and collaboration among participants.
2. Security: Increased data protection and resilience against cyberattacks through cryptographic techniques, decentralized consensus mechanisms, and tamper-proof data structures. Achieved by ensuring data cannot be easily altered or manipulated without the consensus of the network, therefore maintaining data integrity and reducing the risk of fraud and malicious activities.
3. Decentralization: Distribution of authority, control, and computational resources among multiple parties, reducing single points of failure and ensuring no single entity can manipulate the data. Decentralization eliminates the need for central intermediaries, empowering participants to interact directly with each other in a peer-to-peer manner and fostering a more resilient and robust network.
4. Immutability: Permanence and inalterability of records on the blockchain, ensuring data integrity and historical accuracy. Achieved through the use of cryptographic hash functions that create a unique identifier for each block of data, forming a chain of blocks that cannot be altered without invalidating subsequent blocks. This makes it virtually impossible to alter past transactions, providing a tamper-proof audit trail.

5. Trustlessness: Capacity to enable transactions and data sharing between parties without relying on a trusted intermediary. Achieved by implementing consensus mechanisms that ensure network participants can validate and agree on the state of the blockchain without the need for a central authority. This characteristic allows participants to collaborate and transact with confidence, even in the absence of trust relationships.
6. Automation: Execution of predefined actions and processes automatically, reducing manual intervention and human errors. Automation is often realized through the use of smart contracts, which enable automated execution of contractual processes, streamlining operations, and increasing efficiency.
7. Cost Reduction: Reduction of transaction costs, eliminating intermediaries, and streamlining processes. Achieved by removing the need for intermediaries, which results in lower fees, faster transactions, and reduced administrative overhead.
8. Traceability: Comprehensive and end-to-end view of the history and provenance of assets, transactions, or data, enabling enhanced visibility and auditability. Achieved through the use of a shared, distributed ledger that records every transaction or data update, creating an immutable and transparent record easily accessed and verified by all participants.
9. Auditing: Streamlining and simplifying an auditing process by providing a transparent, immutable, and verifiable record of transactions and data. The inherent characteristics of BT, such as transparency and immutability, facilitate a more efficient and accurate auditing process, reducing the time and resources required for audits and enhancing compliance and regulatory reporting.

10. Real-Time Processing: Enabling faster and more efficient transaction processing and data updates in real-time or near-real-time. Real-time processing is facilitated using consensus mechanisms and distributed ledger technology that allows for rapid validation and confirmation of transactions, reducing latency and ensuring up-to-date data is available to all participants.
11. Disintermediation: The removal of intermediaries from processes and transactions through the use of BT, enabling direct, peer-to-peer interactions between parties. Achieved by decentralizing authority and control, eliminating the need for third parties to validate, authenticate, or facilitate transactions, and streamlining processes to increase efficiency and reduce costs.
12. Micropayments: The facilitation of small-value transactions using BT, enabling efficient, low-cost, and near-instantaneous transfers of value. Micropayments leverage the decentralized nature of BT and its ability to process transactions without the need for intermediaries, reducing transaction fees and processing times.
13. Legally Binding Recording and Timestamping: Creating a secure, verifiable, and legally binding record of transactions, documents, or data, along with a tamper-proof timestamp that provides proof of existence and authenticity. Achieved through the combination of cryptographic techniques, immutability, and decentralized consensus mechanisms, ensuring records are recognized as valid and enforceable by relevant legal and regulatory authorities.
14. Security and Risk Management: The enhancement of security measures, reduction of risk, and prevention of fraudulent activities. Achieved by leveraging the transparency, immutability, and decentralized nature of BT, which creates a tamper-proof and

resilient system that is less vulnerable to fraud and single points of failure. The distribution of risk among network participants helps ensure the integrity and security of the network, even in the face of adversarial behavior or unforeseen events. Moreover, the reduction of information asymmetry and the elimination of intermediaries contribute to more secure transactions and processes, resulting in a more robust risk management framework.

15. Reduction of Redundancy: Elimination of duplicate or unnecessary data and processes leading to more efficient and streamlined operations. Achieved by maintaining a single, shared, distributed ledger that serves as the authoritative source of truth for all participants. This ensures data is consistent and up-to-date across the network, reducing the need for separate, siloed databases or systems, and minimizing data replication and synchronization efforts.
16. Enhanced Information Sharing: Improvement of information exchange and collaboration between ecosystem stakeholders, fostering trust and more equitable outcomes. Achieved by providing a transparent, shared, and verifiable record of transactions and data that can be accessed and analyzed by all participants. This ensures that all parties have access to the same information and can make informed decisions based on a common understanding of the data, reducing information asymmetry and promoting more effective collaboration and decision-making.

- Implementation Complexity

1. Low: Blockchain implementations that require minimal modifications to existing systems and processes, with a relatively straightforward development and deployment process.

2. Medium: Blockchain implementations that involve moderate changes to existing systems and processes, with a more complex development and deployment process that may require additional resources and expertise.
3. High: Blockchain implementations that necessitate significant alterations to existing systems and processes, with a highly complex development and deployment process that demands substantial resources, expertise, and time.

- Ecosystem
  1. Internal: Blockchain implementations primarily involving stakeholders within an enterprise, focusing on internal processes and systems.
  2. External: Blockchain implementations primarily involving stakeholders outside the enterprise, focusing on collaboration with partners, suppliers, customers, or other external entities.
  3. Mixed: Blockchain implementations involving a combination of internal and external stakeholders, addressing both internal processes and external collaboration.
- Regulatory and Compliance Considerations
  1. Low: Blockchain implementations with minimal regulatory and compliance requirements, allowing for a more flexible development and deployment process.
  2. Medium: Blockchain implementations with moderate regulatory and compliance requirements, necessitating additional attention to legal and regulatory considerations during development and deployment.
  3. High: Blockchain implementations with extensive regulatory and compliance requirements, demanding significant focus on legal and regulatory aspects during

development and deployment, potentially affecting the implementation timeline and complexity.

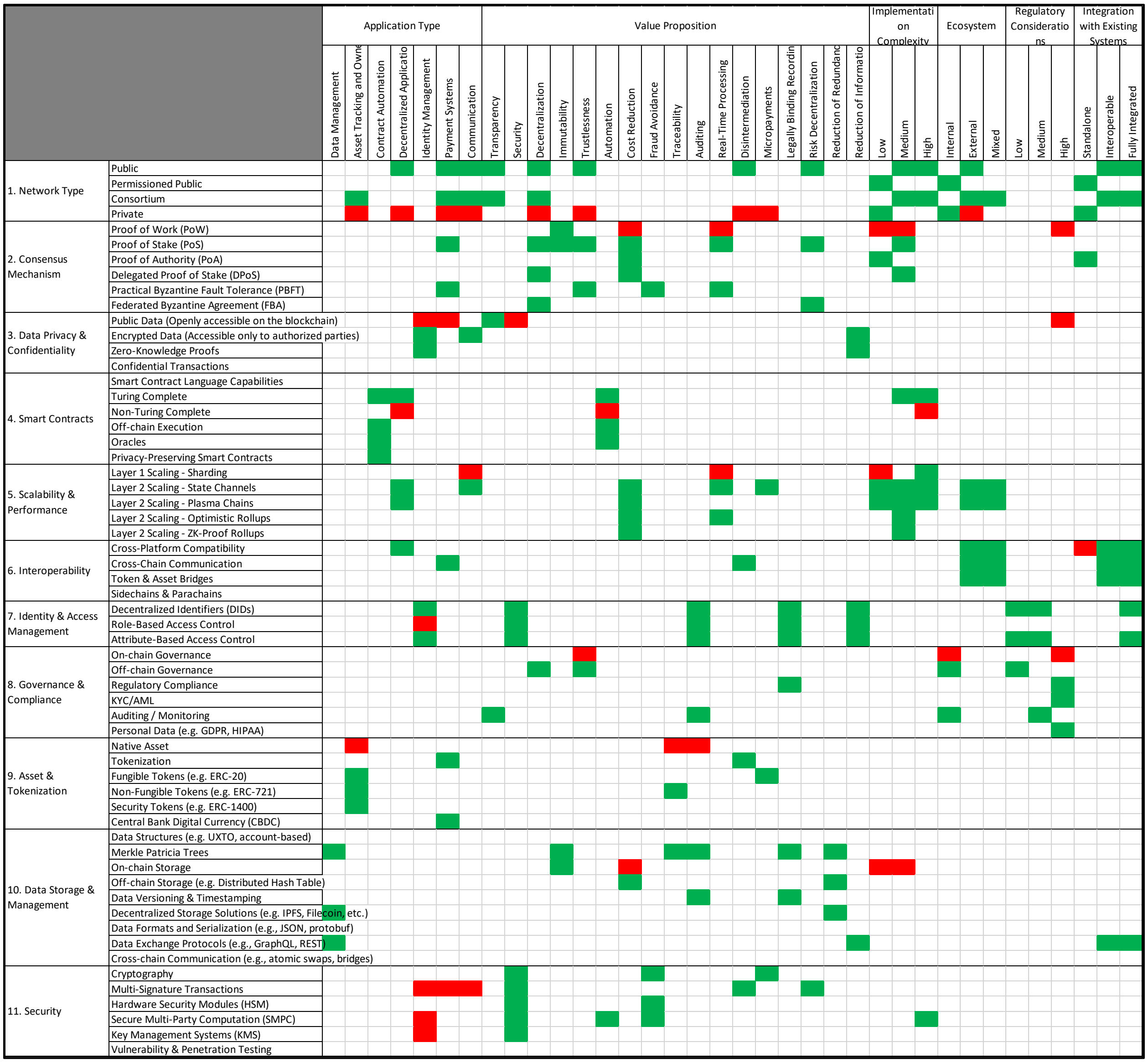
- Integration with Existing Systems
  1. Standalone: Blockchain implementations that function independently of existing systems, with minimal interaction or reliance on legacy infrastructure.
  2. Interoperable: Blockchain implementations that can interact and exchange data with existing systems, enabling a more seamless integration while still maintaining a level of separation from legacy infrastructure.
  3. Fully Integrated: Blockchain implementations that are deeply embedded within existing systems, requiring significant modifications to legacy infrastructure and a higher level of integration complexity.

Guidance Using the Taxonomy Matrix

The resulting taxonomy matrix (Figure 4) is structured with BT design characteristics along the y-axis and BT enterprise use case characteristics along the x-axis. The matrix offers a comprehensive framework for evaluating the suitability and interoperability of various enterprise blockchain configurations. Each cell in the matrix represents an intersection between a design characteristic and a use case characteristic. Intersecting cells marked in red signify non-suitability due to inherent incompatibilities or limitations in the design characteristic to meet desired outcomes of the use case characteristic. On the other hand, cells marked in green reflect high suitability, where design characteristics are optimally suited to the use case characteristics in terms of functionality, performance, or compatibility. Blank cells denote context-dependent relationships that require detailed analysis based on specific project constraints, requirements, or other contextual factors.

Figure 4

Taxonomy Matrix of Enterprise Blockchain Technology Design and Use Cases



Key: Highly suitable combinations; Unsuitable combinations; Context dependent

Using the taxonomy matrix involves identifying relevant use case characteristics based on organizational needs and priorities. Subsequently, practitioners must examine the matrix's intersections to assess the suitability of design characteristics concerning the identified requirements. By focusing on the green intersections, practitioners can identify ideally suitable design characteristics while avoiding unsuitable choices marked in red. In the case of blank cells, a deeper analysis is necessary to discern the best fit in the context of specific project needs, constraints, and objectives. Utilizing the taxonomy matrix in this manner will enable practitioners to make informed decisions regarding their enterprise blockchain projects.

Both the design characteristics and use case characteristics taxonomy satisfy Nickerson et al.'s (2013) objective (i.e., all available object studied, no changes after the last iteration, each dimension consisting of at least one component, and all objects are unique) and subjective (i.e., concise, robust, comprehensive, extendible, and explanatory) ending conditions.

Application of the Taxonomy

The taxonomy matrix developed represents a comprehensive framework for evaluating and selecting appropriate design characteristics for specific enterprise BT use case characteristics. By systematically analyzing the compatibility between the design characteristic taxonomy and the use case taxonomy, practitioners, researchers, and decision-makers can gain valuable insights into the optimal design choices for their specific blockchain applications. The taxonomy matrix also enables users to identify potential mismatches or issues that may arise due to the incompatibility of certain design choices with the requirements of the use cases. Together, compatibility and unsuitability can guide the decision-making process when designing or choosing a blockchain solution for specific enterprise use cases. I will show an example of how to apply the taxonomy to a real-world enterprise BT use case, Digital Royalties Payment Solution.

An enterprise seeks to implement a blockchain-based digital royalties payment solution to enhance transparency, trustlessness, and automation in calculating creative royalty's payments for a digital ecosystem of stakeholders. The current royalties management process is opaque and highly manual, causing significant trust issues and frustration from the upstream stakeholders who receive royalties payments. The primary use case characteristics for this application include:

- Application Type: Smart Contracts
- Value Proposition: Transparency, Trustlessness, Automation
- Implementation Complexity: High
- Ecosystem: Mixed (internal and external)
- Regulatory Considerations: High
- Integration with Existing Systems: Interoperable

Using the taxonomy matrix, the use case characteristics map to suitable design characteristics and exclude potential mismatches. For instance:

- Application Type - Smart Contracts: For a digital royalty tracking system, smart contracts serve as an essential element to automate business logic and distribution of royalties. The ideal design option, in this case, would be Turing Complete Smart Contract Language, which enables the implementation of complex logic and ensures flexibility in automating royalty calculation and distribution.
- Value Propositions - Transparency, Trustlessness, Automation: The digital royalties tracking use case requires high levels of transparency, trustlessness, and automation. For transparency, a Public or Consortium Network Type combined with Data Privacy and Confidentiality options such as Encrypted Data with selective access could be considered. Trustlessness can be achieved using a Decentralized Network Type, a consensus mechanism like Proof of Stake or Practical Byzantine Fault Tolerance, and Off-chain Governance. Automation can be ensured through Turing Complete Smart Contracts, Oracles for external data inputs, and Off-chain Execution mechanisms.

- Implementation Complexity - High: A high implementation complexity demands advanced features like scalability, performance, and security. Adopting Layer 2 Scaling solutions such as State Channels, Plasma Chains, or Optimistic Rollups can improve transaction throughput and processing speed. Advanced security measures such as Secure Multi-Party Computation, Cryptography, and Hardware Security Modules can be employed to safeguard the system against potential vulnerabilities.
- Ecosystem - Mixed: A mixed ecosystem requires seamless communication and collaboration between different organizations and platforms. Interoperability solutions such as Cross-Platform Compatibility, Cross-Chain Communication, and Token and Asset Bridges are integral to supporting interactions between multiple blockchain networks and external systems.
- Regulatory Considerations - High: High regulatory considerations necessitate compliance with data protection laws and financial regulations. Identity and Access Management with features like Decentralized Identifiers and Attribute-Based Access Control, and Data Privacy and Confidentiality with Encrypted Data, should be incorporated. Additionally, adopting consensus mechanisms such as Proof of Stake or Practical Byzantine Fault Tolerance ensures regulatory compliance due to their energy efficiency and potential tamper resistance.
- Integration with Existing Systems - Interoperable: For interoperable integration, Cross-Platform Compatibility, Cross-Chain Communication, and Token and Asset Bridges are crucial in enabling seamless interactions between the digital royalties tracking system and other platforms. Data Exchange Protocols (e.g., GraphQL, REST) facilitate data communication between the blockchain and external systems.

These options provide an initial starting point; a more detailed analysis based on the specific context and requirements of the project should be conducted to finalize the design. However, based on the summarized options, a few BT solution features emerge which meet the needs of the use case:

- Ethereum: Ethereum supports a Turing complete smart contract language (Solidity), and it can work as a public or consortium network. Ethereum has transitioned to a Proof of Stake consensus mechanism. Off-chain governance is carried out by the Ethereum community through Ethereum Improvement Proposals (EIPs). Layer 2 scaling solutions like Optimistic Rollups and ZK-Rollups are available, and advanced security measures are inherent to the protocol. Ethereum also supports interoperability with other networks such as Polkadot and Cosmos through bridge technologies. Identity and access management features can be built using smart contracts and Ethereum-based solutions like uPort. Ethereum does not natively support data encryption, but there are third-party solutions like NuCypher that can provide this functionality.
- Polkadot: Polkadot can fulfill most of the requirements. It uses a Turing complete smart contract language (Substrate, which can compile into various languages including Solidity), and it uses a variant of Proof of Stake as its consensus mechanism. Polkadot supports both public and consortium networks through different parachains. It emphasizes interoperability between different blockchains, and it also supports Layer 2 scaling solutions. Polkadot has a decentralized off-chain governance model with on-chain voting. It can support data privacy and confidentiality through

parachains that implement these features. Identity and access management features can be implemented at the parachain level.

- Cosmos: Cosmos supports a Turing complete smart contract language and can be configured as a public or consortium network. It uses a variant of Proof of Stake as its consensus mechanism, and it also supports interoperability between different blockchains via the Inter-Blockchain Communication (IBC) protocol. Cosmos provides off-chain governance and also has Layer 2 scaling solutions. Data privacy and confidentiality can be handled by specific zones, which are application-specific blockchains connected to a central hub. Identity and access management features can be implemented at the zone level.

Discussion and Contributions

Several theoretical implications emerge from this study. The taxonomy matrix provides a structured framework to understand the complex landscape of BT, contributing to increased conceptual clarity of the domain. By dissecting various blockchains into individual design components, this study offers a systematic approach to analyzing and comparing different blockchain architectures, thereby enhancing the theoretical understanding of BT. The taxonomy proposed helps bridge the gap between different disciplines, including IS and computer science, by examining the relationship between enterprise blockchain design characteristics and use case characteristics. This interdisciplinary approach allows for a more holistic understanding of BT and its potential applications, enriching the theoretical foundation across various academic fields.

This research contributes to the methodological advancements in the field of BT by proposing a taxonomy matrix as a systematic approach to analyze and compare different blockchain architectures. This methodological approach can inspire future research that examines other emerging technologies, resulting in improved rigor and relevance of academic research in the business and IS domains. Complexities in BT design have commonalities with other emerging technologies, such as quantum computing and generative AI. This research can inform a methodological approach to domain taxonomy for other technologies with no dominant design and design attributes that continue to evolve. Theoretical insights resulting from my research can inform policymakers and regulators about the potential benefits and challenges of implementing BT across industries. The comprehensive taxonomy matrix can contribute to the development of evidence-based policies and regulations that foster responsible and sustainable adoption of BT.

The practical implications of my research can impact the development and adoption of BT across industries. The comprehensive taxonomy matrix developed provides valuable insights for practitioners of enterprises seeking to explore or increase adoption within their stakeholder ecosystems. Enterprises can leverage the taxonomy matrix to make informed decisions regarding the selection, design, and implementation of BT solutions tailored to their specific use case requirements. Understanding the relationship between BT design characteristics and use case characteristics is critical for enterprises to identify the most appropriate blockchain architectures for their use cases and to eliminate design characteristics that do not satisfy the value proposition enterprises seek from adopting BT.

This research helps address the need for standardization and increased interoperability within the blockchain ecosystem. Identifying commonalities and differences in BT design characteristics across various use cases can contribute to the development of industry-wide standards that enable seamless integration and collaboration among different BT platforms. The taxonomy matrix can also foster cross-industry collaboration. Introducing synergies between different enterprise use cases and BT design characteristics fosters the exchange of knowledge and best practices among industry stakeholders. This collaborative knowledge could lead to the creation of innovative, cross-industry blockchain enhancements and solutions.

The taxonomy proposed helps better understand the BT landscape, and it can also be used as a structured framework for evaluation that leads to increased adoption success of blockchain solutions. Enterprises looking to understand the potential benefits and challenges of implementing BT should find a taxonomy matrix a valuable artifact, whether they are exploring BT for the first time or whether they already have prior experience.

Limitations and Future Research

This study provides a taxonomy matrix for enterprise BT design characteristics and use case characteristics, but there are limitations that could result in future research directions. BT innovation continues to evolve, resulting in new protocols, techniques, and solutions. The taxonomy presented may require updates and refinements to remain relevant and comprehensive. Future research should monitor and incorporate these advancements to ensure the taxonomy reflects the state-of-the-art in enterprise BT. Additionally, future research can dig deeper into specific design characteristics, exploring their nuances, trade-offs, or synergies in detail to provide an understanding of real-world implications for enterprise blockchain applications.

The taxonomy matrix can be further validated and refined through case studies and empirical analysis of real-world enterprise blockchain implementations. Examining the successes or failures of enterprises seeking to adopt different design characteristics for specific use cases can contribute to the development of best practices for enterprise BT adoption. BT touches various research domains, such as computer science, economics, law, and business management. Future research can incorporate cross-disciplinary perspectives to better understand the multifaceted nature of enterprise blockchain applications, particularly between design characteristics, use case characteristics, and implications to broader organizational constructs.

Addressing these limitations will enable scholars to contribute a more nuanced and robust understanding of enterprise BT, guiding practitioners and decision-makers in designing and implementing effective blockchain solutions for various use cases across industries.

Conclusions

BT has the potential to transform various business domains, including financial services, Internet of Things (IoT), consumer electronics, insurance, energy, logistics, transportation, media, communications, entertainment, healthcare, automation, and robotics. Since the emergence of Bitcoin in 2009, awareness of BT has grown significantly, with the financial industry being the first to adopt these innovations. In response to the increasing interest in blockchain, this study presents a taxonomy matrix that examines the intersection of enterprise blockchain design characteristics and enterprise use case characteristics. The matrix aims to facilitate the exploration of design domains, as well as the implementation, deployment, and performance measurement of different blockchain architectures, catering to various enterprise use cases.

The proposed taxonomy matrix dissects various blockchains into individual functional or logical components and identifies possible alternative layouts based on component-based design. By examining the relationship between blockchain design characteristics and use case characteristics, the matrix provides valuable insights for software architects, companies, and regulators seeking to create globally compatible, cross-industry, and cost-effective solutions.

This work was inspired by the ongoing proliferation of enterprise BT adoption failures, non-interoperable BT platforms, and the need for BT standards. While this study contributes to the development of these standards, it is possible that the standardization process may take several years to produce concrete solutions, particularly for complex scenarios. Regardless, this taxonomy matrix represents a timely and valuable exercise that serves as preliminary support for those interested in reducing BT complexity and increasing the success of BT projects. I recognize that this taxonomy matrix, though useful, is preliminary and may evolve into more complex iterations in the future. By providing a comprehensive overview of the relationship between enterprise blockchain design characteristics and use case characteristics, this matrix can serve as a foundation for future research and development in the field of BT.

CHAPTER 4: FACTORS LEADING TO ADOPTION WITH CONTINUED USE IN LARGE ENTERPRISES

Introduction

BT represents a unique shift in how enterprises apply technology to manage data and business network participation. Still in its infancy, the blockchain domain has seen relatively few cases of true adoption through scaled, continued use, despite the majority of enterprises considering BT as a strategic priority (Deloitte, 2020). Literature exploring blockchain adoption to date is either largely conceptual or it discusses adoption in the context of behavioral intent.

The promise of BT for enterprises can be considered in the context of business ecosystems. Every enterprise has one or more partners across its value chain as well as the networks in which it participates. Efficiencies in data sharing across an enterprise and its partners can improve margins, therefore increasing value for shareholders through improved enterprise financial health or capital allocation to high-value activities. Coleman (1988) found that network density, defined as trust and close support, is a key moderator in network value realization. BT enables trust between enterprises in a fair, distributed manner, minimizing network structural issues such as actor power imbalance. Enterprises embracing technology and tools to strengthen ecosystems can acquire new capabilities and achieve system value (Singer, 2022).

The objective of this study is to identify common success factors of early organizational adopters of BT in the form of continued use. Drawing on foundations of technology adoption and network theory, I explored success factors in four major areas: technological, organizational, environmental, and inter-organizational.

This research leveraged the cross-case study method, which allowed extraction of insights on common success factors across cases, as well as contrast case study of an organization that failed to adopt BT. Eisenhardt (1989) states that the selection of the appropriate population controls for irrelevant variation and helps bound the generalized findings. I followed the design principles that cases should be purposeful, and I seek variation along different dimensions, including across geographic footprint, industry, technology span, and size. Drawing on dimensions of interest extracted from technology adoption theory, I analyzed within-case similarities, coupled with cross-case differences across technological, organizational, environmental, and inter-organizational dimensions to define patterns of interest. This methodology allows for insights to be derived beyond initial impressions through the use of structured and diverse lenses on the data (Eisenhardt, 1989).

Literature Review

Blockchain Technology

In 2008, a pseudonym (Satoshi Nakamoto) released a whitepaper describing an innovative peer-to-peer digital currency called Bitcoin (Nakamoto, 2008). Satoshi built on previous work by Haber and Stornetta (1991), who designed a secure, sequenced chain of information cryptographically. The term blockchain has been defined in several ways; however, a generally accepted definition includes that it is a distributed public ledger (Zhao et al., 201) or meta-technology, which is a technology made up of several technologies (Mougayar & Buterin, 2016). Blockchain is a chain of blocks acting as a linear ledger of all transactions made on the chain of blocks. For the original decentralized case of Bitcoin, miners compete to solve a cryptographic challenge to mine a block and add to the chain every 10 minutes, a design characteristic known as proof of work. Bambara and Allen (2018) state blockchain is a "distributed, transparent, immutable, validated, secured, and pseudo-anonymous database existing as multiple nodes such that if 51 percent of the nodes agree then trust of the chain is guaranteed" (p. 1).

Mougayar and Buterin (2016) conceptualize blockchain from technical, business, and legal standpoints. Technically, the blockchain is a back-end database that maintains a distributed ledger that can be inspected openly. Business-wise, the blockchain is an exchange network for moving transactions, value, and assets between peers, without the assistance of intermediaries. Legally speaking, the blockchain validates transactions, replacing previously trusted entities.

Characteristics that define BT together make BT unique and unlike any technology seen to date. Distributed Ledger Technology (DLT) has been around as a concept since the Roman empire, when the banking system allowed people to participate in transactions across different regions of the vast empire. From a technology perspective, DLT concepts and networks have been around since the advent of P2P network design. However, the Byzantine Generals Problem (BGP) could not be solved by DLT alone. The problem is described as an analogy to several generals surrounding an enemy city for attack. The generals must communicate with each other to gain consensus on attack plan. However, there is no way to prevent or predict a corrupt general from plotting against the others from achieving their goal. Bitcoin's PoW consensus innovation was the first solution to the BGP, allowing each node on the network to work individually yet, at the same time, maintain a synchronized and distributed ledger without coordination or communication (Blockstreet HQ, 2018).

I used Sai et al.'s (2021) holistic BT architecture framing, which is based on the Open Systems Interconnection (OSI) layered model that describes the functions of a networking system. Because blockchain is one technological solution to DLT, utilizing a similar layered model to the generic OSI model and adjusting for BT is appropriate.

Current literature on barriers to BT adoption in business enterprises is largely conceptual in nature. Because of the nascent state of blockchain, there are limited studies on the reasons why a specific blockchain was selected and adopted. This gap in knowledge is critical to address for practitioners to understand the factors that lead to continued use of BT. If an enterprise's decision on BT adoption was merely selecting a technology for the transactional activities BT can provide, little need for my research beyond validating BT value in specific industries or use cases would be warranted. However, BT adoption introduces new considerations because of a new type of business and technology network. For instance, an enterprise has opportunities to directly be involved in BT protocol governance and consensus.

BT adoption brings unique characteristics and challenges enterprises must consider (Treiblmaier, 2019), including versioning, hard forks, multiple chains, regulatory opaqueness, shared governance, and viable ecosystems. Blockchains are typically not products of a single company, but a network of computers that can evolve in various ways, out of a particular enterprise's control. These changes may or may not be in the best interest of an enterprise that has already deployed BT into its business processes.

One key characteristic of BT is distributed trust, so management behavior and risk tolerance must change. At best, embedding an enterprise's resources in a private consortium blockchain governance and consensus will allow the enterprise to have a strong voice in the network's design. At worst, drawing on the true value of a decentralized blockchain, an enterprise influencing the network will be on a level playing field with each governing node, including retail investors, government, competitors, and random supporters.

Chen et al. (2021) noted that enterprise users and their decision-making in a decentralized system is currently understudied, resulting in limited insights of how incentive design impacts

BT adoption. Entrepreneurial teams that build the blockchain infrastructures attempt to design enough incentives to draw users to their protocol. The interaction of user and consensus provision and, more generally, the service provision and demand in a platform economy can bring new economic insights for blockchain applications (Chen, 2021). Moving beyond conceptual models toward empirical evidence of blockchain value and identifying enterprise-required characteristics for adoption represents a significant under-researched yet critical space in the BT literature to facilitate adoption and achieve the promise of BT.

Technology Adoption

The nascent nature of BT and its use in enterprises has so far resulted in limited real-world examples of adoption with continued use and, consequently, studies beyond the conceptual stage are scarce. As Leible et al. (2019) state regarding the selected BT for their study, "a few of them disappeared, got canceled with official statements of their developers, or are subjectively dead based on long-time inactivity" (p. 19). In the end, a blockchain alone represents a database with a unique bulk of characteristics but requires application within a business context to support purpose and functionality to achieve value creation for enterprises.

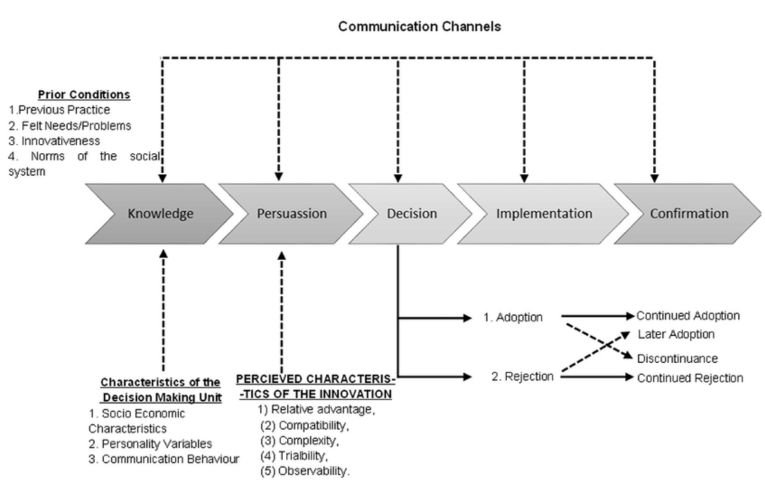
Innovation and technology adoption theories generally conceptualize adoption as behavioral intent. In this study, I seek adoption with continued use as an outcome. Cooper and Zmud (1990) proposed a six-stage IS diffusion process within enterprises: initiation, adoption, adaptation, acceptance, routinization, and infusion. In this model, the adoption phase occurs when an enterprise agrees to invest in the technology. Adaptation is the initial development, installation, and maintenance period. As the technology is embedded in the process and staff are encouraged to use the technology, it moves into the acceptance stage. Routinization is when the technology is no longer viewed as extraordinary, and utilization of the technology has become a normal activity. Finally, in the infusion stage, the enterprise seeks increased organizational effectiveness through a comprehensive and integrated manner to support higher-level operational activities. I define adoption with continued use as enterprises which have moved the BT into the routinization and infusion stages. This involves consistent utilization, upgrades, or even expanding the technology's use to other areas within an organization to ensure the technology remains relevant and valuable to the organization over time.

Researching adoption of an emerging technology merely in context of use will inherently include insights from those cases where the technology was explored but failed to be embedded in process and behavior through a clear organizational decision to invest in production scale solutions (Rogers, 2003). By isolating use cases which have led to continued adoption, hypotheses and valuable insights for enterprises seeking to explore BT can be derived.

Rogers' (2003) seminal work on technology adoption included a construct called the Innovation-Decision Process. The Innovation-Decision Process is an information-seeking and information-processing activity, where an individual is motivated to reduce uncertainty about the advantages and disadvantages of an innovation (Figure 5).

Figure 5

The Innovation-Decision Process



The knowledge stage is when an organization becomes aware and seeks information about an innovation. The persuasion stage includes a more subjective, or feeling-centered, evaluation of innovations to decide to adopt. The decision stage involves a choice to adopt or reject an innovation. Rogers (2003) defines the decision to adopt as fully utilizing an innovation because it is the optimal course of action available. The implementation stage is when an organization attempts to use the innovation. There are varying degrees of uncertainty with implementation outcomes which can cause problems. In the confirmation stage, the individual seeks to validate the decision to adopt. The greatest factor in moving forward to implementation is a belief that the innovation will meet desired outcomes. Adopters tend to seek confirmation bias in this stage so attitudinal awareness of influences during this stage becomes crucial.

The TOE model (Tornatzky & Fleischer, 1990) specifically addresses technology adoption at the enterprise level and has been shown to be effective (Zhu et al., 2006). The TOE model focuses on three categories to explain technology adoption within enterprises: the technological category, which includes the characteristics and usefulness of the technology; the organizational category, which explores internal characteristics like management, employees, and capabilities; and the environmental category, which takes into account industry, social, and political attributes, including competitors and business partners (Chiu et al., 2017).

To add structure to the technology context of TOE, many studies integrate Rogers' (1995) DOI theory into their conceptual model. The integration of DOI and TOE has been validated as a combined model to explain enterprise-level adoption of innovations (Chiu et al., 2017; Hsu et al., 2006; Piaralal et al., 2015). Particularly, the characteristics of innovation, including relative advantage, compatibility with pre-existing systems, complexity, trialability, potential for reinvention, and observability have been shown as significant predictors of technology adoption in multiple studies (Rogers, 1995). BT can be leveraged for both data representing the digital world and for data representing the physical world. Multiple technology adoption frameworks, such as TOE and DOI, have been combined to address blockchain research studies bridging the digital and physical worlds. Both Wang et al.'s (2010) research on enterprise adoption of RFID in the manufacturing sector and Thomas and Espadanal's (2014) research on cloud computing adoption in the service industry combine TOE and DOI theories. Because new technologies can be complex, combining more than one theoretical model may be appropriate to gain a better understanding of enterprise adoption (Oliveira & Martins, 2011).

Integrated TOE-DOI studies across industries, technologies, and organizational characteristics have led to varying results across the five DOI innovation characteristics. One study found that compatibility is the most important factor in technology adoption (Zhu et al., 2006). Wang et al. (2010) found compatibility positively correlated to adoption, while complexity was negatively correlated. Another study found that relative advantage and complexity were inversely correlated to adoption (Low et al. 2011). A study on information and communications technology adoption found relative advantage, compatibility, complexity, observability, and security were significant factors in enterprise adoption (Sin Tan et al., 2009). However, a study on cloud computing adoption found that trialability does contribute to the reduction of uncertainties in adoption (Alshamaila et al., 2013).

Annabel et al. (2015) studied enterprise adoption of cloud computing. In their research, organizational context attributes included management support, enterprise size, and technological readiness, which have been validated as significant factors in innovation adoption. Jeyaraj et al. (2006) found top management support as one of the best predictors of enterprise innovation adoption. Lee and Xia (2006) found organization size had a positive correlation to innovation adoption, with several moderating variables. Hameed et al. (2012) studied the correlation between organizational readiness and enterprise innovation adoption and found organizational readiness to be the largest factor.

The complexity of BT has created a significant knowledge gap in even the most experienced organizational decision-makers. Very few ecosystem technologies exist that force an organization to make technology adoption decisions in tandem with business partners. One such technology, electronic data interchange (EDI), is simply an automated, standard data feed across two companies (Huang et al., 2008). Malone et al. (1987) introduced the inter-organizational dimension required to achieve value through EDI in the form of efficiencies. EDI research captures similar insights expected in the BT domain. For instance, enterprise experience with older technology may impede openness to adopt new technologies because of switching costs (Zhu et al., 2006).

Research Methodology

To explore success factors leading to the successful adoption of BT within large enterprises, I employed a multiple case study design (Fereday &Muir-Cochrane, 2006). A case study is an exploratory, qualitative methodology and it is a suitable approach in contexts with limited prior empirical research (Creswell and Creswell, 2017), which is the context of blockchain, where there is scarce theory and empirical research on the factors that lead to continued use. Case study research results in the generalization of a phenomenon with the goal of expanding existing theory through theoretical propositions (Yin, 2017). While case study research does not often lead to grand theories applicable to an entire domain of research, case studies are important in grounded theory within context to begin identifying theoretical constructs which are testable, novel, and empirically valid (Eisenhardt, 1989).

In this study, a cross-case analysis of different blockchain projects led to propositions that sought to identify factors beyond the context of any individual firm and use case. Both primary and secondary data were collected from five successful BT adoption cases, and one failure, to provide sufficient heterogeneity and variation to develop the propositions (Eisenhardt, 1989).

Study Population and Sampling

I targeted large enterprises for this study. Large enterprises were chosen to explore complexities that small and medium enterprises (SMEs) do not necessarily encounter. For instance, SMEs typically have one decision maker, often the CEO or CTO, for adopting technology. Large enterprises typically exhibit decision-making complexity based on the involvement of IS and other business functions. No universal definition of large enterprise exists globally, so I leveraged the U.S. Small Business Administration definition, which defines large enterprises across all industries as ones with more than 500 employees.

To strengthen the theoretical propositions arising from the analysis, case study variability was a key consideration (Table 2). Striving for variation within a multiple case study research agenda can expand the application of theoretical constructs arising from the analysis. The case studies included five successes and one failure as a control to contrast and strengthen propositions. Variation across case studies included: geographic footprint (local [e.g., one country], regional, and global), industry, technology span (e.g., intra-enterprise and inter-enterprise), and size.

Table 2

Description of Case Studies

Company	Founded	HQ	Employees	Revenue	Geographic Footprint	Industry Type	Result
Birra Peroni	1846	Rome, Italy	1,500+	€350 million (2019)	Europe, North America	Beverage - Alcoholic	Success
Takeda	1781	Tokyo, Japan	50,000+	$31.9 billion (2020)	Global	Pharmaceuticals - Biotech	Success
ANSA	1945	Rome, Italy	1,100+	N/A	Italy, Europe	Media – News Agency	Success
Aretaeio Hospital	2005	Nicosia, Cyprus	1,000+	N/A	Cyprus	Healthcare - Hospital	Success
Microsoft XBox	2001	Washington, USA	2,400+	$4.76 billion (2022)	Global	Media – Gaming	Success
Healthcare	Decades old	USA	Tens of thousands	$10s of billions (2022)	Global	Healthcare	Failure

While Birra Peroni, Takeda, ANSA, and Aretaeio are companies from different industries with distinct products or services, there are some commonalities that can be observed in their innovation strategies. First, all four companies leverage the use of modern technology and digital solutions to enhance their products or services. For example, Birra Peroni introduced eco-friendly packaging and low-alcohol beverages, Takeda's plasma division leverages technology to improve patient outcomes, ANSA uses digital technology to improve its reporting capabilities and distribution channels, and Aretaeio Hospital utilizes state-of-the-art medical equipment and electronic medical records to improve patient care.

Second, most of these companies, if not all, have invested in collaboration and partnerships with external stakeholders to support their innovation strategies. Takeda collaborates with external partners to expand its product portfolio, Birra Peroni partners with food and hospitality brands to offer complementary products, ANSA collaborates with news enterprises to provide high-quality news content, and Aretaeio Hospital collaborates with healthcare providers to enhance patient care.

Lastly, these companies prioritize customer or patient engagement as a critical component of their innovation strategies. For example, Birra Peroni engages with its consumers through targeted marketing campaigns and social media channels, Takeda's plasma division focuses on patient outcomes and satisfaction, ANSA uses social media to engage with its audience and provide personalized content, and Aretaeio Hospital empowers patients to take an active role in their care. Microsoft Xbox maintains backward compatibility allowing users to continue to enjoy their favorite game versions or games from previous consoles.

Overall, while there are differences in the products or services that these companies offer, their innovation strategies share some commonalities based on their focus on technology, collaboration, and customer or patient engagement.

Data Collection and Analysis

Data collection was systematic and robust through a multi-dimensional approach to address gaps in obtaining proprietary primary data. Data collection for each case was done through multiple sources, including documentation (e.g., company reports, news articles, websites, and other business reports), interviews, and direct observations, consistent with appropriate sources for case studies (Yin, 2017). The advantages of interviews in qualitative research include gathering historical information not easily gathered from other data sources and allowing the researcher to have control over the line of questioning (Creswell, 2018). Interviews were semi-structured, covering categorical dimensions while allowing for flexibility to understand other adoption factors which emerged during the discussion.

Technology innovation in large corporations typically requires external information systems and advisors or consulting firms to help develop the technology's innovation strategy and to support implementation. In some cases, enterprises may directly work with a BT foundation (e.g., VeChain) to develop and implement use cases. I followed Ravasi and Turati's (2011) suggestions to mitigate the potential risks associated with using consulting firms as primary data sources. I selected consulting firms with a reputation for objectivity and impartiality, clearly defined the research questions and objectives of the study before engaging with the consulting firms, established clear guidelines for data collection and analysis, and conducted triangulation of data from multiple sources. These measures were taken to ensure the data collected from these interviews is objective, valid, and free from bias. Also, the consulting partners' expertise and insights enhance the quality of the research.

For each case study, the firm's websites were accessed to gain data about the organization itself and, where possible, the BT use case itself, including details about drivers of adoption. For instance, the website for Ashai (Birra Peroni's parent company) offered details about the reasons and benefits for exploring the blockchain traceability effort, and ANSA includes a detailed description of the technology and how customers should consider the use cases when interacting with the news agency reporting articles.

Other principles of case study data collection were followed, which maximize the benefit of the data collection methods, including creating a case study database to separate and compile data in an orderly manner and maintaining a chain of evidence to increase the construct validity of the information. Caution was exercised when considering data from social media sources because it can overwhelm the researcher, and it is not easy to cross-check the reliability of sources or the data itself (Yin, 2017).

A thematic method of data analysis was used. The thematic analysis technique includes examining, ascertaining, analyzing, recording, and unveiling themes that are relevant to the subject studied (Boyatzis, 1998; Braun & Clarke, 2006) and is considered a primary method for analyzing qualitative data due to the multidimensional nature of qualitative data (Braun & Clarke, 2006). More specifically, a hybrid approach (Boyatzis, 1998) was employed because codes were both theoretically and empirically driven.

The data analysis of the interviews involved three stages. In stage 1, the constructs of TOE and I (Inter-organizational) were developed from the literature. To code the raw data into the appropriate categories, the definitions and descriptions of four categories of the T-O-E-I framework were written in simpler language using code names and a definition associated with each code. In Stage 2, all interviews were transcribed and imported into NVivo software. The transcripts were then coded manually into appropriate categories. Subsequently, a consistency check was ascertained for all the codes to see how credible and applicable they are for successive raw data. To ascertain reliability, the initial coding exercise was checked by three reviewers with combined academic and blockchain expertise to relate the codes and supporting evidence against the categories. In Stage 3, codes were further validated through the application of adoption factors found in other data sources analysis for each case study. Constructs were strengthened by the additional validation of data insight across all data sources, particularly in determining factors common to all or most of the case studies.

Case Studies of Blockchain Technology Projects

Case Study Organization & Process

The organization for the case studies focuses on details for each individual case, followed by a cross-case analysis. Each case study is structured in three parts: an overview of the organization, a description of the use case, and data on the successful design and implementation of the use case. These were categorized according to technological, organizational, environmental, and inter-organizational factors. To analyze the case studies, I employed the TOE framework as a lens for coding the data because it is well-suited for examining emerging technology adoption in large enterprises. Separating TOE dimensions in describing each case study offers several benefits, including a structured approach to perform a systematic analysis. A thorough examination of each dimension helps to identify patterns and trends within and across the cases. Each case study can be analyzed using a consistent framework, improving comparability and leading to a more robust understanding of the critical success factors in blockchain adoption. Dividing the case studies into the TOE dimensions also helped to isolate specific aspects of blockchain adoption, allowing a more nuanced understanding success factor context. Examining each dimension individually as well as comprehensively helps to identify generalizable insights applicable to a broader range of contexts which is important for early technology adoption research to develop guidelines for successful blockchain adoption in large enterprises, as well as advancing academic knowledge of the domain.

Our initial theoretical construct added inter-organizational factors, such as trust and power dynamics as an additional coding lens, which is an important context for blockchain applications. In traditional systems, other organizations are external to the firm, but many blockchain applications leverage inter-organizational coordination and information exchange. Therefore, I found a strong interconnected nature between environmental and inter-organizational factors and combined the two. Environmental factors encompass the external context in which the organization operates, such as regulatory requirements, industry standards, market competition, and other stakeholders or organizations not directly involved with the blockchain solution. Inter-organizational factors refer to the relationships and collaborations between the enterprise and its partner ecosystem.

Birra Peroni

Birra Peroni is a renowned Italian beer brand, established in 1846 in Rome, and wholly owned by the Asahi Group, a global beverage company. Birra Peroni has maintained a reputation for quality by utilizing the finest ingredients, including malted barley, hops, and their own yeast strain, which creates a unique flavor profile. This commitment to quality has helped the brand maintain a loyal customer base and establish itself as a leading beer brand in Italy and globally. Birra Peroni's approach to quality aligns with the concept of value co-creation, as customers are actively involved in creating value by paying for and consuming high-quality products.

Furthermore, Birra Peroni's innovation strategy includes experimentation with new flavors and product lines, including gluten-free and low-alcohol options to expand its market reach and attract new customers. Birra Peroni has engaged in partnerships with other brands and companies to create unique and limited-edition beer varieties, enabling the company to cater to diverse customer preferences and create new market segments. Birra Peroni's innovation strategy aligns with the concept of open innovation (Chesbrough, 2003), where firms collaborate with external partners to develop new products or services.

Birra Peroni's innovation strategy has been recognized by industry experts, with the company winning several awards for its innovative products and sustainable practices. For example, in 2019, Birra Peroni announced that it had achieved zero waste to landfill across all its production sites, a significant milestone in its sustainability efforts. In 2020, the company won the "Best Innovation in Packaging" award at the World Beverage Innovation Awards for its new infinitely recyclable aluminum bottle, which is made from 100% recycled aluminum and can be recycled an unlimited number of times without losing its quality.

In 2018, Birra Peroni partnered with EY and a local startup, Posti, to implement a blockchain-based traceability system to enhance its supply chain management and ensure the quality and authenticity of its products. BT is used to track the entire brewing and distribution process, from the selection of raw materials to the delivery of the final product to the end consumer. The desired outcome for Birra Peroni is better visibility into the production process to ensure quality, while consumers could prove the authenticity of the materials involved in the beer they purchased.

Birra Peroni's blockchain-based traceability system works by recording every step of the brewing and distribution process using the blockchain. The system starts with the selection of raw materials, such as hops and barley, and tracks their journey from the farm to the brewery. Each batch of hops is assigned a unique identifier, and its journey is recorded on the blockchain as it is transported from the farm to the brewery. Once the raw materials have been sourced and verified, the brewing process begins. As each batch of beer is brewed, it is assigned a unique identifier and recorded on the blockchain. The blockchain records important information such as the ingredients used, the date and time of the brewing, and the temperature and pressure at various stages of the process. As the beer is bottled and packaged, the blockchain continues to record its journey from the brewery to the distributor and ultimately to the end consumer. This creates a tamper-proof and immutable record of the product's journey, providing enhanced transparency and trust.

To eliminate doubts in the consumer's mind about product quality, technology solutions needed to be open and transparent, not controlled by Peroni itself. The Ethereum blockchain was originally chosen due to unique features such as smart contract capabilities allowing for the automation of processes and execution of rules without the need for intermediaries. Additionally, Ethereum's scalability, security, and established network were essential factors in Birra Peroni's decision to satisfy key business requirements.

However, variability in gas fees associated with writing to the Ethereum blockchain forced Birra Peroni to move to Polygon, an Ethereum-compatible protocol designed to maximize scalability with minimal, predictable transaction fees. Ethereum can take 30 minutes to mine a block, but on Polygon blocks are created within seconds. In addition, the carbon footprint from Ethereum at the time was in conflict with Birra Peroni's sustainability objectives. Polygon is scalable, transparent, and sufficiently decentralized. Birra Peroni's solution requires an annual token throughput of thousands, which is easily achievable with Polygon's maximum of 7,000 transactions per second. Birra Peroni leveraged a third-party blockchain management solution to connect to the blockchain itself, relieving the costs of initializing and maintaining a node.

The tracking along the supply chain leveraged ERC721 tokens, a non-fungible digital asset representing the characteristics of a batch and uploaded onto the blockchain by using an encrypted hash function. Traceability initially included the ability to understand which batches of malt were contributing to a specific batch of brewing. The solution was expanded upstream from malt houses to be able to trace back to local farms producing the barley and seeds of each bottle of beer using tokenization. Birra Peroni data was extracted from the production management system, based on SAP. Data captured on the blockchain included raw material data, brewing data, quality control data, and supply chain data.

BT was part of a suite of innovative products within Birra Peroni's global rebranding initiative to support the communication of product quality to consumers. EY was selected as an implementation partner because of its BT experience and Posti was used as an expert in using technology to improve the customer's experience. Both Posti and EY led innovation sessions to design and define where to put the traceability QR code on the bottle and what data the customers would see when the QR code is scanned. The output of the innovation sessions was tested on consumers to refine prior to scaling.

Key Birra Peroni sponsors of the project were the CEO and the head of Corporate Affairs because they were the representatives and leaders of the company's digital transformation and sustainability journey. From an execution standpoint, the head of the supply chain was the day-to-day sponsor, orchestrating several cross-functional departments and outside suppliers to make the project a success.

The main goal of this project was to increase revenue through rebranding. The rebranding meant to highlight corporate values of transparency, authenticity, innovation, quality, while cultivating a cooler brand to make Birra Peroni more appealing to the new young consumers. Cost reduction through higher efficiencies and better decision-making was a secondary benefit. Following the initial success in traceability, the solution expanded to support integrating traceability data into ESG reporting and quantifying carbon footprint savings.

In recent years, institutional investors and consumers alike have become very attentive to the sustainability of products. Birra Peroni highlighted their sustainability focus using blockchain in their annual regulatory financial filings for investors. In addition, the blockchain utility is highlighted on their corporate website in discussing sustainable ingredients and local farmers. From a regulatory standpoint, data on the blockchain met existing beverage and packing standards so there were no adverse regulatory considerations or impact.

Change management was a key focus on the supplier side. Malt houses needed to digitize business workflows for the solution to work. Ensuring accuracy in collecting data from malt houses and farmers is a very complex process requiring additional investment. Farmers are not always as digitally mature as the rest of the ecosystem, so this required major change management to bring them along the journey. Malt houses and farmers had an incentive to adopt and provide data because the increase in Birra Peroni sales drives increased production and revenues for them as well. In addition, information from suppliers enabled by the BT solution has supported better decision-making in Birra Peroni.

ANSA

Founded in 1945, Agenzia Nazionale Stampa Associata (ANSA) is one of the oldest and most reputable news agencies in Italy. As the news industry has rapidly evolved with digital technology, ANSA has consistently adapted its innovation strategy to meet the changing needs of its audience, utilizing digital technologies to expand its reach and deliver timely and accurate news to its audience. ANSA's innovation strategy places a strong emphasis on audience engagement and leverages artificial intelligence to better understand its audience's needs and preferences to automatically generate news articles tailored to their interests.

ANSA's innovation strategy has been recognized by industry experts, with the company winning several awards for its innovative products and services. In 2020, ANSA won the "Best Use of Data in a Breaking News Story" award at the Data Journalism Awards. The award recognized Ansa's coverage of the COVID-19 pandemic, which leveraged data visualization and analysis to provide timely and accurate updates to its readers.

In recent years, the dissemination of disinformation and fake news has become an increasingly pervasive issue, prompting calls for innovative solutions to address the crisis of trust in journalism. In response, ANSA launched a blockchain-based system called ANSAcheck in 2020 to bolster the veracity and traceability of its news articles. ANSAcheck verifies the origin of news a consumer sees on ANSA platforms and is based on the Ethereum public blockchain. A green digital ANSAcheck certificate on an article informs readers the article is verified and has not been manipulated or spoofed. Since its launch, ANSAcheck certifies thousands of news articles an hour resulting in millions certified since inception. The solution has been well received by ANSA customers and, currently, ANSA is exploring additional solution enhancements to drive new business models across the news value chain. One example is the business-to-business (B2B) flow of news to build industry standards that protect and authenticate data shared across news agencies.

When an ANSA journalist writes a news article, the content undergoes review and fact-checking by editorial staff. Upon approval, a unique cryptographic hash is generated for the article, which serves as a digital fingerprint encapsulating the content's metadata, including authorship, publication date, and version history. The hash is then added to a new block, along with other pertinent metadata. Subsequently, the block is broadcasted to the permissioned network for validation. Nodes within the network engage in a consensus process to validate the block. Once consensus is achieved, the block is appended to the existing chain, creating an immutable and tamper-evident record. End users can click on an ANSA check logo included on a news article page to verify the authenticity by comparing its hash against the stored data on the blockchain. The decentralized and transparent nature of the blockchain ensures the provenance and integrity of the information, instilling trust in the news content.

The ANSAcheck leverages EY’s OpsChain Traceability technology to generate a hash function stored as a token on the blockchain. The OpsChain platform is built to enable blockchain benefits seamlessly on top of existing enterprise platforms and applications. When a consumer clicks on an article, the web browser compares the article to the immutable, encrypted hash function stored on the chain to see if it is a match. If matched, the article will generate the green certificate, which can be clicked to show meta-characteristics of the article on the blockchain. These meta-characteristics include the transaction ID, article title, content hash, event, and time stamp.

The organization opted for a permissioned blockchain network, ensuring that only approved entities (e.g., journalists, editors) can participate in the consensus process and validate transactions. This decision aligns with ANSA's business model, which emphasizes the importance of maintaining control over the news production process while ensuring a high degree of transparency and credibility. Because of the infrastructure required, it has moved from initially running on Ethereum to Polygon for efficiency and sustainability. This move reduced the cost of transactions due to batching into blocks of hundreds. Polygon uses PoS consensus that completes the transaction confirmation process in a single block. By doing so, Polygon can maintain fast transaction processing speeds. Polygon's average block processing time is 2.1 seconds, and the transaction fee is around $0.01.

Batching of new articles involves aggregating the news through a Merkle tree to generate the hash function that gets written to the blockchain. Each time an article gets updated with new, verified information from the publisher, that article is included in a subsequent Merkle tree hash to ensure the verifiability is always accurate in real-time. The CEO of ANSA was the key sponsor of the initiative, providing the resources and investment required to build and scale. The IT team was a highly competent group which enabled ANSA to accelerate internal knowledge of BT and to understand complexities across the implementation process.

ANSA communicated the solution in detail to consumers through press releases as well as a dedicated landing page, including the direct benefits for the readers. The landing page can be accessed through a clear ANSAcheck button at the top of the ANSA home page, signaling the importance of the solution for ANSA customers.

ANSAcheck is consumer-centric through the validation of the on-chain hash. Instead of merely providing a trusted checkmark on articles, consumers can click on the checkmark, which will bring them to the actual transaction on the blockchain for which the hash function was generated, which consequently provides immutability of news content to consumers. The solution has strengthened the reliability of ANSA articles with the ecosystem of publishers that partner with ANSA. The certification engine has opened new business models for those publishers because they can put the certification on their own consumer-facing platform. In addition, ANSAcheck tackled news content verification first, leaving future evolutions to take on the more complex misinformation and disinformation of content within each article. An example of this evolution includes secure communication and collaborative reporting. Secure communication securely and transparently shared information among journalists, editors, and external sources to enhance the confidentiality of sensitive information and protect the identify of anonymous sources.

Takeda

Takeda is a Japanese pharmaceutical company, established in 1781, that has evolved into a global organization with a strong commitment to innovation. The company's innovation strategy encompasses research and development (R&D) in various therapeutic areas, including oncology, gastroenterology, and neuroscience. Takeda's R&D efforts include open innovation, whereby the company collaborates with external partners to develop new products or services. In

2021, Takeda won the "Best Partnership Alliance" award at the Asia-Pacific Bioprocessing Excellence Awards for its collaboration with the National University of Singapore to develop a new manufacturing process for biologics.

Takeda's plasma division is a critical component of its innovation strategy. The division is responsible for the production of plasma-derived products, such as immunoglobulin, albumin, and coagulation factors, used to treat various medical conditions. The plasma division has a history of successful innovation, with Takeda being one of the first companies to develop plasma-derived products in Japan. The company has since expanded its plasma division globally and has a strong presence in the U.S., Europe, and Asia. The company has formed partnerships with various plasma collection centers, providing a reliable supply of raw materials for the production of plasma-derived products. Additionally, the plasma division has collaborated with other pharmaceutical companies to develop new plasma-derived products, expanding its product portfolio and market reach.

Plasma-derived therapies are critical to treat various medical conditions, including immunodeficiency disorders, hemophilia, and other blood-related diseases. Ensuring the traceability and safety of plasma-derived products throughout the supply chain is vital to protecting patients and maintaining regulatory compliance. In response to these challenges, Takeda adopted BT to enhance the traceability and security of its plasma supply chain, benefiting both patients and stakeholders.

Takeda's implementation of BT centered on creating a tamper-proof, transparent, and auditable record of plasma-derived product provenance. The company selected a permissioned blockchain network, allowing only authorized entities (e.g., suppliers, manufacturers, distributors, regulators) to participate in the consensus process and access the shared ledger. This approach aligned with Takeda's commitment to ensuring the security, privacy, and regulatory compliance of sensitive data across the plasma supply chain.

The integration of Takeda's blockchain solution within its plasma supply chain is anchored on collecting and digitizing relevant data at each step of the supply chain pertaining to plasma-derived products, including donor information, plasma collection, testing, processing, and distribution. The collected data are encrypted and added to a new block, accompanied by a unique cryptographic hash that serves as a digital fingerprint, encapsulating the product's metadata. Stakeholders within the plasma supply chain can access and verify the product's provenance through the shared ledger, ensuring transparency, accountability, and regulatory compliance. Blockchain facilitates real-time information sharing and enhances trust among participants.

The technology solution was initially designed to tackle internal process problems and to gain an early understanding of how to tokenize data. Tokenization was an innovative solution to provide more granular tracking of individual plasma components through the product lifecycle. Tokenization also streamlined the transferability and ownership of plasma units through the supply chain. It was important to spin up an environment quickly, resulting in the selection of PoA governance to enable speed in execution. In PoA-based networks, transactions and blocks are validated by approved accounts, known as validators. Takeda identified which systems across the plasma ecosystem were needed for the BT solution to interact with, the data to be collected, how to standardize formatting, and how to translate the data to tokens tracked on a blockchain. Tokenization allowed Takeda to prevent double counting, eliminate inventory mix-ups, and verify plasma content in the final product for patients and healthcare providers. Because tokenization was required, a protocol that had a seamless smart contract capability was a key business requirement. To minimize any end-user engagement with the blockchain, user-friendly interfaces were developed to display transaction data and token tracing.

The CIO of the Plasma Therapies division of Takeda was the overall sponsor, with buy-in from the CFO. He understood the value of a public blockchain solution and, through his commitment to that sentiment, drove the blockchain solution to be built on top of Ethereum's technology. The CFO saw this project as a way to increase visibility into inventory and explore future business models to collateralize. Transparency and authenticity into plasma characteristics could act as an alternative asset class for institutional investors or open up new avenues of revenue to customers like research institutions.

The innovation arm of the IT group was involved in the project as it saw the opportunity to learn about BT as potentially disruptive technology. Takeda had previous experience experimenting with Hyperledger and it leveraged knowledge from those experiments to accelerate the plasma use case. Once in production, DevOps for the solution was minimal, although it still required maintenance due to impacts of upstream system changes over time. For instance, if a data attribute on the donor system changes that is not recognized by Takeda's solution, it will be instantly recognized but requires support to troubleshoot and remedy.

Pharmaceutical companies are required to comply with strict healthcare data privacy requirements, so the only information stored on-chain is the token ID and hashed metadata. The hashed metadata gives the location of the plasma data on the internal Takeda server environment. All data attribute relating to patients or donors is strictly maintained off-chain. The plasma-derived therapy market is projected to increase to over $30 billion per year by 2030. Takeda distinguishes its offerings within the highly competitive plasma manufacturing landscape by emphasizing product transparency as a key differentiating factor.

Due to the initial solution focused on improving internal efficiencies, Takeda did not engage with its ecosystem's stakeholders during development, resulting in some broader use case requirements not being met. When later approaching partners and suppliers, it was difficult to prove the value to gain consensus and buy-in from the broader distributed network. In particular, collaborating with the specialty pharmacies that distribute the plasma therapies could have built the last mile of traceability into the solution. The benefits of this last mile for plasma traceability for patients and plasma infusion centers came in the form of transparency and immutability of plasma content and supply chain activity. Takeda gained greater insights into plasma consumption, resulting in better forecasting and commercialization strategies.

Aretaeio

Aretaeio Hospital is a leading healthcare facility in Cyprus that provides a range of medical services, including diagnostics, surgery, and rehabilitation. The hospital has a strong focus on innovation and has implemented several strategies to enhance patient engagement and improve healthcare outcomes. Aretaeio's innovation strategy has been recognized by industry experts. In 2020, Aretaeio won the "Best Hospital for Patient Experience" award at the Healthcare Business Awards for its patient-centered care initiatives.

One key aspect of Aretaeio's innovation strategy is its use of digital technologies to provide remote consultations and improve patient access to care. According to the hospital's website, Aretaeio has implemented a telemedicine platform that allows patients to consult with doctors and receive medical advice from the comfort of their own homes. The hospital has implemented a digital patient portal that allows patients to access their medical records, schedule appointments, and communicate with their doctors online.

Another key aspect of Aretaeio's innovation strategy is its focus on patient-centered care. The hospital has implemented several initiatives to improve the patient experience, including a patient satisfaction survey program and a patient engagement platform that allows patients to provide feedback on their care experiences. Aretaeio has invested in patient education and health promotion programs to help patients better understand their health conditions and make informed decisions about their care.

In 2020, Aretaeio, in partnership with technology consultant iDante, developed a blockchain-based digital app, E-HCert, which allows patients to access and control their COVID-19 antibody test results. The application has since expanded to include other medical information, diagnostics, and lab results. The E-HCert application helps organize and properly flow patient information across the stakeholders that need access to patient care. Patients are also able to digitally access medical records at any time, and they are notified of new data uploaded to the system through application notifications. The data is real-time, includes user-friendly visualizations, and is designed to improve doctor-patient communication and diagnosis across the different providers caring for each patient.

Aretaeio developed a BT application that was flexible to the evolving business needs of the hospital ecosystem. The selection of VeChain as a protocol was driven by the need for sufficient decentralization, but a priority requirement of scalability and security. For scalability, VeChain offers the ability to handle thousands of transactions per second at an average cost of less than .02 cents. VeChain provides innovative functionality such as multi-party payment (MPP) smart contracting. The MPP innovation allows iDante to pay for gas fees to write on the blockchain and, in turn, charge a predictable fee to Aretaeio for transactions. This enables Aretaeio to use the blockchain without having to hold and self-custody cryptocurrency. The solution connects seamlessly to the hospital data center, complementing data origination to ensure transparency and trust. Data security requirements for patient health is the stringent all over the world. The solution required hospital decision-makers to be absolutely confident about the security of the solution, including tamper proofing and prevention of unauthorized access.

One of VeChain's innovative enterprise-focused attributes is called MPP. MPP enables multiple parties to jointly pay for a single transaction, streamlining and simplifying complex payment processes. VeChain is one of the most sustainable blockchains with carbon emissions for running the entire blockchain for a year equivalent to just 51 transactions in Ethereum. The VeChain foundation acts as an enabler of the platform, leveraging technology partners to co-create solutions for enterprises seeking BT solutions.

Aretaeio created a dedicated twin server for the hospital, which acted as the test environment. The test environment was established within weeks to meet the needs of the original use case of COVID-19 test results. The design of the consumer-facing application was prioritized to ensure maximum useability and patient engagement. Experts in user experience were brought in to conduct focus groups that obtained user needs, thereby including patient input in the functionality design.

Sponsorship for the project came from both the CFO and CIO of Aretaeio. Aretaeio decision-makers had knowledge of enterprise BT and understood that VeChain was an established protocol with real-world use cases publicly revealed in the media. Aretaeio used an agile mindset to ensure the solution evolved to the needs of the hospital's healthcare practitioners and patients, which was evident through the evolution and expansion of patient data offered on the application.

The solution development process included a discovery session between the hospital and the implementation partners to align on deliverables, timelines, and costs. The initial solution took three months to develop. In addition, legal and compliance personnel who validated the solution complied with various local and European Union General Data Protection Regulation (GDPR) data and digital regulations. Throughout the development process, and as the solution has continued to evolve, consistent communication and collaboration between the implementation partners, the hospital team, and the auditors was a priority.

The application design satisfies the European Union's GDPR by putting only the hash function associated with anonymized encrypted data. GDPR includes the right to be forgotten, or an individual's right to erase his or her data, which is in direct contrast with the decentralized nature of a blockchain. The E-HCert solution provides a hash function of the internal system the data resides, therefore eliminating any identifying information for a patient and satisfying GDPR.

Building something powerful for patients required something cool and easy to use. The hospital remained focused on putting the patient at the center of the solution. Patients felt empowered based on the access and control of their healthcare data, improving the trust between the hospital and its customers.

Microsoft Xbox

Microsoft Xbox is a business unit of Microsoft Corporation, focused on the development, production, and distribution of gaming consoles, games, and related services. Since its inception in 2001, Xbox has played a pivotal role in shaping the gaming industry through continuous innovation and cutting-edge technology. Xbox's innovation strategy revolves around three core pillars: immersive gaming experiences, accessibility, and community building.

Differential offerings, such as the Xbox Adaptive Controller launched in 2018, represent a groundbreaking example of gameplay innovation. It allows gamers with limited mobility to customize their controller setup. The 2019 AbleGamers' Accessibility Award honored the Xbox Adaptive Controller for its exceptional inclusivity and adaptability for gamers with disabilities. Xbox also received the Golden Joystick Award for "Best Gaming Hardware" in 2020, recognizing the Xbox Series X as a groundbreaking gaming console.

The accelerated growth of the gaming industry, in both users and revenue, over the last decade has resulted in an exponential increase in game publishers. Game sales and in-game purchasing royalties constitute the majority source of revenue for game publishers and intellectual property (IP) holders. Managing and disbursing royalties in a transparent and timely manner has historically been a challenge, requiring innovative solutions across the complex ecosystem of stakeholders. Royalty settlements are opaque and burdensome to verify payments based on contract types and terms for specific products. In response, Microsoft Xbox developed a BT solution, the Rights and Royalties (R&R) platform, to streamline the tracking and payment of royalties, with the aim of fostering trust and efficiency within its gaming ecosystem.

Over 1,500 game publishers contract with Xbox, resulting in tens of thousands of contracts. A typical contract has around 15 different logical terms and over 40 calculations applied to each quantity of sale. Game publishers also require upstream royalty payments to creative stakeholders, such as graphic artists. Prior to the R&R solution, settlements on royalty payments were manually calculated on spreadsheets and took up to 45 days for payment.

The company chose a permissioned blockchain network consistent with Microsoft Xbox's commitment to safeguarding the privacy and security of sensitive financial data across its gaming ecosystem. Stakeholders within the ecosystem could access and verify royalty-related transactions through the shared ledger, promoting transparency, accountability, and trust. The R&R platform facilitated real-time information sharing, reducing payment delays and improving efficiency in the royalty management process.

Converting each contractual detail into smart contracts is unfeasible. Xbox, in partnership with EY, created a contract smart engine that extracted key contractual terms and converted them into digital smart contracts. The solution was built using the Quorum blockchain on the Microsoft Azure cloud computing platform. Eight blockchain protocols were assessed for the solutions, but Quorum was chosen because it stood out based on its ability to offer significant scalability and privacy, both required for millions of royalty transactions per year. The nodes for the solution sat within the same Azure instance. Game publishers welcomed the value of BT, but most were not willing to invest in maintaining a node on their own infrastructure.

Integration into transaction data workflows were built so metadata about licensing agreements and sales were imported into the smart contract engine, providing near real time visibility into sales and royalties. Unstructured data was from the various sources of retail sales were cleaned and standardized. The royalty data, along with pertinent metadata, was encrypted and added to a new block, accompanied by a unique cryptographic hash that encapsulates the transaction information. Due to the solution integrating with payments, strict financial controls and compliance considerations were required. Integration with Microsoft's ERP systems was necessary to feed into the SAP invoicing modules, bounded by the traditional treasury rails, which is the infrastructure that allows money to flow from a payer to a payee.

Microsoft and EY built a business intelligence capability into the solution, allowing Microsoft to run analytics on transactions and improved business financial planning. The business intelligence interface can proactively communicate potential risks to compliance guardrails.

The Microsoft Xbox CFO was the key sponsor of the initiative, as he sought a financial return on the investment through process efficiencies. Also in support of the initiative was the Azure business unit, which had a strategic objective of building out and scaling its enterprise blockchain as a service market offering. While there was an existing royalties group, the solution required technology training to improve competency in order to scale adoption, particularly in smart contract development. The royalties group identified accountable resources for the solution. Over the last five years, the team has improved competency and it has relied on EY as a technology partner to improve the solution.

The initial pilot focused on one game publisher contract and was developed in four weeks. The solution was then scaled in three-month intervals, providing valuable insights and learnings as additional features and workflows were integrated.

Overcoming the various financial, operational, digital privacy, and confidential data compliance considerations were the largest hurdles to overcome in the solution design. For instance, financial controls were required to be embedded in how the contract engine processes the royalty workflows. Once the solution calculated the royalty payment, it got fed back into SAP for payment. The settlement from SAP then got ingested back into the contract engine to be part of the system of payment records between parties.

Microsoft worked from the beginning with game publishers, gathering desired business requirements from their perspective. The overwhelming need was to provide transparency to improve forecasting and business planning. The R&R platform included a game publisher view, providing real-time transparency into its royalty transactions, which could be as fast as four minutes from when sales information is generated in the system. The platform interface provided the value of a blockchain solution without having to engage with the contract engine by extracting the smart contract data and processing backend workflows. Part of the interface included a feedback mechanism for game publishers to communicate back to Microsoft Xbox any desired enhancements of the platform to meet their needs. Upon launch, Microsoft used multiple media outlets to highlight the royalty payment solution, including Forbes. Once partners saw the value of the portal, the R&R platform saw an acceleration of adoption across the vast game publishing community.

Enterprise Use Case Failure

A leading global company, hereafter referred to as Company X based on its request to remain anonymous, has been at the forefront of innovation in its industry since its inception. With a diverse portfolio of cutting-edge products, the company has been a market leader.

Company X's innovation strategy is centered around a commitment to a culture of innovation, through internal efforts and collaborations with external partners. A key component of Company X's innovation strategy is its willingness to explore and invest in emerging technologies, such as blockchain, artificial intelligence, and advanced data analytics. Integrating these technologies into its core processes aims to drive efficiency, optimize decision-making, and deliver better solutions to customers. Strategic partnerships and alliances with industry stakeholders, academic institutions, and technology providers help the company access new ideas, expertise, and resources to accelerate product development and address customer needs.

The industry has become increasingly data-driven and managing third-party agreements (TPAs) to access, purchase, and monitor data is an essential hurdle. Current processes and procedures cause difficulties in verifying, retrieving, and consolidating data across multiple vendors. In addition, limited visibility into the end-to-end TPA process and no systematic way to monitor and document TPA creates compliance risks. Company X sought to enhance its data asset and information access management governance process by building a blockchain-enabled TPA. The solution aimed to improve the visibility and auditability of data assets, streamline the TPA process, reduce overhead costs, and minimize the risk of data misuse and non-compliance.

The TPA management solution utilized Guardtime's Keyless Signature Infrastructure (KSI) BT hosted outside of Company X's infrastructure environment. Key components of KSI include Merkle Trees and Merkle Hash Chains, which enable the aggregation of a vast number of requests per block and quick cadence (1.5 block/second). The permissioned Calendar Blockchain ensured linear growth with time, independent of load (2-4 GB/year), and maintained a widely distributed database with periodically published top hashes. Most blockchain protocols use public key infrastructure (PKI) for data validation and security, however, KSI blockchain uses a keyless signature scheme which eliminates the need for key management.

Shared data was extracted and stored in an AWS S3 bucket in a database table form. Monitoring access required customization on accessing software. Guardtime's solution allowed for the design of a validation of cryptographic signatures through a standard math proof. The solution facilitated TPA initiation and signing while capturing necessary data fields. It supported the upload of manual PDF request forms, approval of TPA requests, and electronic signing of TPAs. The solution offered a secure environment for data provisioning and disabled data access after TPA expiry, confirming data destruction through self-attestation. Additionally, the system provided visibility into data access and user login, automated system and email notifications, and offered monitoring metrics dashboards.

The project was sponsored and funded by the VP of the central innovation group. The project leveraged outside parties to design and implement the pilot. One of the external collaborators was a large consulting firm, and the other was a blockchain development company. Workshops were held to gain alignment on the technical approach, milestones, user acceptance criteria, and delivery timelines. The functional business units accountable for TPA management were involved but availability was limited, and there was confusion regarding the proof-of-concept environment setup and the roles of the two external parties.

Once the pilot was complete, the business process owner decided not to move forward with further exploration. The feedback given was that the blockchain solution was overkill for the problem and scalable costs proposed by the external parties could not be justified. Company X's cloud service provider had proposed a technical solution to TPA management which would cost a fraction of the customized blockchain development solution.

Company X is responsible for onboarding data vendors, managing data acquisition mechanisms, and ensuring regular data refreshes. The pilot did not involve any TPA management providers or data stewards. Typically, for innovation efforts in Company X, there are representatives for legal, compliance, and regulatory involved to facilitate design decisions dealing with project risk. However, the pilot did not include these representatives.

Results

The case study method facilitated a grounded approach to identify success factors within and across case studies. The purpose was to facilitate any exploratory insights that could result in new theories or constructs. Overall, the findings suggest success factors related to BT adoption in terms of continued use are largely consistent with other technologies. Interestingly, some interesting nuances emerged, particularly in BT adoption.

Table 3 summarizes the key findings drawn from each case study across technological, organizational, and environmental dimensions. Success factors have been classified into strong and modest factors based on their frequency of occurrence across the cases. Strong success factors are bolded and were observed in four or five cases, whereas modest success factors appeared in one, two, or three cases.

Table 3

Dimensions and Factors of Blockchain Adoption

Dimension	Factor	Insight	Count
Technology	Compatibility	**Solution designed for optimal user experience**	**5**
		Solution was complementary to existing systems, not a replacement	**5**
		Solution designed for optimal data attributes (e.g. security-metadata within a hash, non-fungibility-ERC721, etc.)	**4**
		Data was standardized	3
	Complexity	Blockchain technology exposure to end users is minimal	3
		Solution satisfied the application trilemma - utility, usability, coolness	2
	Observability	**Relenquishment of enterprise control through building on public protocol**	**4**
		Dynamic, agile solution which can evolve (e.g. adapt to envionmental changes, additional value propositions, etc.)	**4**
	Relative Advantage	**Blockchain trilemma satisfied by prioritizing security and scalability at expense of decentralization**	**5**
		All stakeholder incentives designed into solution	**4**
		No enterprise requirement for owning crypto or running consensus node	**4**
		Confidence in blockchain protocol enduring over time	2
	Trialability	Pilot timeline and cost aligned with experience of other innovative technologies	3
		Test environment for pilot available to validate security and use case value	3
Organizational	Communication	Communication with sponsors and compliance/auditors throughout process	2
		Stakeholder feedback process established	2
		Included end user in solution design process	2
		Proactive end user communication (e.g. education, benefits, etc.)	3
	Organizational Context	**Innovation is an organizational priority (i.e. willingness to invest $/resources)**	**5**
		C-Suite sponsorship	**5**
		Strong collaboration between enterprise, solution consultant, and/or blockchain stakeholders	**5**
		Clear and trusted value proposition	**4**
		Blockchain solution supports broader enterprise goals (e.g. sustainability, rebranding, digital transformation)	**4**
	Organizational Knowledge	**Knowledge of blockchain technology and use cases**	**4**
		Identified competent technical owner(s) for solution	**4**
		Prior internal projects exploring blockchain technology	2
Environmental & Inter-Organizational	Regulatory	**Compliance with regulatory (i.e. GDPR, HIPAA) data requirements**	**4**
		Regulatory/compliance resources involvement in solution design	2
	Partner Support	Supported change management efforts with ecosystem partners	1
	Trust	Ecosystem partner trust and willingness to invest to meet solution needs	2

Technological

In the technology dimension, compatibility emerged as a critical success factor. Solutions designed for optimal user experience and those complementary to existing systems, rather than serving as replacements, were observed in all five cases. Furthermore, four cases emphasized the importance of solutions designed for optimal data attributes, such as security through metadata within a hash and non-fungibility using the ERC721 token standard. Relative advantage was also a strong success factor. All cases considered the importance of prioritizing security and scalability at the expense of decentralization in the blockchain trilemma. Four cases reported prioritizing the design of a solution that addressed all stakeholder incentives and did not require enterprises to own crypto or run a consensus node. Observability factors, such as relinquishment of enterprise control through building on public protocol and having a dynamic, agile solution that can evolve were reported in four cases.

Complexity played a less prominent role. Two cases reported the importance of satisfying the application trilemma, which includes utility, usability, and coolness, while three cases mentioned the significance of minimizing BT exposure to end users. Trialability was also a factor across three case studies, with the ability to design and execute a pilot aligned with previous technology experience as a factor. The ability to test the value proposition and validate technology security in a pilot was a success factor in three of the cases.

Organizational

The cross-case study revealed the importance of organizational context in the adoption of BT. Innovation as an organizational priority, with a willingness to invest resources, was a success factor in all cases. Sponsorship from the C-Suite and strong collaboration between the enterprise, solution consultant, and blockchain stakeholders were also strong success factors, mentioned across all cases. Four cases reported that the blockchain solution was a piece of a broader enterprise strategic priority, such as sustainability, rebranding, or digital transformation.

Regarding modest success factors, communication with sponsors and compliance or auditors throughout the process were emphasized only in two cases. Including end users in the solution design process and proactive end-user communication were reported in two and three cases, respectively. Once the solution was live, the establishment of a stakeholder feedback process was emphasized in two cases. Organizational knowledge factors, such as prior internal projects exploring BT, were observed in two cases.

Environmental and Inter-organizational

In the environmental dimension, regulatory compliance emerged as a strong success factor. Compliance with regulatory data requirements, such as GDPR and HIPAA, was observed in four cases. Various methods to meet data requirements were observed, including hash encryption and hashes referencing internal artifacts and servers, not the actual data itself.

Regarding modest success factors, supporting change management efforts with ecosystem partners was observed in one case. Existing ecosystem partner trust and willingness to invest to meet solution needs were reported in two cases, and the involvement of regulatory or compliance resources in solution design was observed in two cases as well.

Discussion and Theoretical Propositions

Several interesting insights emerged that stand out or contradict common findings in technology adoption research. Six propositions were developed, informed by success factors found across all case studies.

- Proposition 1 – The Blockchain User Experience Proposition: Enterprise blockchain solutions that prioritize optimal user experience will lead to continued use.

Increased exposure to technology typically improves adoption, yet the cross-case results suggest that minimizing end-user exposure to the underlying BT that powers an application is a key contributor to adoption. This may suggest the complexity of BT can be overwhelming and a seamless user experience that abstracts the technology may lead to a more positive response. Providing a user experience that is both intuitive and convenient minimizes friction in users first attempting a technology as well as a desire to continue to use the technology. This is in accordance with both the compatibility and complexity-fit hypothesis of DOI theory (Rogers, 1995). In an enterprise context, technology supplements a business workflow for an individual resource. A blockchain solution should integrate seamlessly into an existing workflow. If a blockchain solution is too complex or difficult to use, it is less likely to be adopted by users beyond the adaptation/pilot stage. In the failure use case, the enterprise neglected to engage the end users in the development process. In addition, multiple additional business process steps were built into the solution workflow, creating unnecessary complexity for users to obtain the proposed business value.

- Proposition 2 – The Blockchain Complementary Systems Proposition: Enterprise blockchain solutions that are complementary to existing systems will lead to continued use.

Unlike other technology adoptions where an enterprise often seeks to replace legacy systems, the cross-case study findings suggest that enterprise blockchain solutions that are complementary to existing systems, as opposed to replacements, are likely to succeed. This is consistent with DOI theory (Rogers, 1995), which suggests technology is more likely to be adopted if it is a good fit within an enterprise. Fit can be defined as the degree to which a specific technology aligns with the needs, requirements, and goals of an enterprise while also complementing its existing systems and processes. Large enterprises often have complex and entrenched systems, processes, and enterprise structures. The value of blockchain is achieved when enhancing enterprise data with blockchain characteristics, such as immutability or decentralization. Blockchain solutions designed to integrate seamlessly with existing structures, without introducing significant changes or disruptions, are more likely to be accepted in organizations. A complimentary solution can be achieved by detailing the current system business processes and taking advantage of existing resources where possible. For example, blockchain applications can be developed to integrate with existing databases, or APIs can be used that interface between the blockchain solution and existing systems. This helps to minimize disruption of existing technology workflows and replacement costs from introducing BT solutions. This finding highlights the importance of interoperability and integration, as opposed to wholesale replacement of existing systems. In the case of the failure, the enterprise developed a solution that required additional system and capability building for the solution to work, such as automated data cataloging. In addition, the solution was not built on the enterprise's internal environment, creating security and access issues for data flow and user access to an external environment.

- Proposition 3 – The Blockchain Trilemma Proposition: Enterprise blockchain solutions require prioritizing security and scalability over decentralization.

BT is often associated with decentralization as a core value proposition. However, as the blockchain trilemma framework suggests, there are fundamental trade-offs in blockchain applications regarding decentralization, security, and scalability. The case study findings indicate that enterprises should prioritize security and scalability over decentralization when having to make tradeoffs in the blockchain trilemma. The success cases suggest that the benefits of BT, such as enhanced security and efficiency, are more critical for enterprise adoption than the ideological appeal of decentralization. This is especially true in public blockchain solutions, as full decentralization is very difficult to achieve at scale and with adequate security with the current universe of layer 1 protocols.

In prioritizing scalability and security over decentralization, perhaps enterprises can determine what is the sufficient level of decentralization that satisfies business outcomes so that it can focus on the trade-offs between security and scalability. This ensures that the blockchain-based solution is robust and reliable, whilst still enabling the benefits of distributed ledger technology. In the case of the failure, the enterprise chose a private, permissioned solution that was centrally controlled, therefore negating the core BT value proposition of creating a trustless environment to share data across the ecosystem of stakeholders.

- Proposition 4 – The Blockchain Innovation Proposition: Enterprises that prioritize innovation will adopt successful blockchain solutions.

An increasingly competitive business landscape requires large enterprises to adopt new technologies to maintain their market position and capitalize on emerging opportunities. BT promises to create this opportunity through decentralization, security, and transparency. By prioritizing innovation, an enterprise signals its commitment to staying ahead of the curve, and this proactive mindset is critical for the successful integration of blockchain solutions within its existing infrastructure. The case study results suggest that when an enterprise is willing to invest resources, including capital, time, and workforce, in the exploration and implementation of BT, it demonstrates a level of commitment that can be critical for overcoming many barriers in the adoption of BT solutions, including resistance to change, regulatory hurdles, and technical complexities. The enterprise highlighted in the failure case drives innovation through a centralized function. The value chain functions are lean and have limited ability to create resource capacity for disruptive or radical innovation, leading to incremental innovation activities and minor improvements in process or financial impacts.

- Proposition 5 – The C-Suite Blockchain Sponsorship Proposition: C-suite sponsorship of blockchain solutions will lead to successful adoption.

While leadership support is often found in technology adoption, the emphasis on C-suite sponsorship in all cases suggests that the adoption of BT may require even stronger top-down support, given its transformative and disruptive nature. The case study results show that technology initiatives that are not sponsored by executive-level decision-makers are often hampered by a failure to obtain resources and behavior necessary to adopt the technology solution. With emerging technology such as BT, the complexity of understanding, developing, and implementing requires additional sponsorship beyond executives at a functional level. C-level executives are in a unique cross-functional and authoritative position to recognize the potential of this technology and its ability to benefit their enterprise. Furthermore, by providing resources such as budgets, personnel, and executive sponsorship, these senior leaders are critical to the successful adoption and continued use of BT in large enterprises. In the case of the failure, the use case was sponsored by the central innovation lead, who held a VP title and had limited influence on functional priorities and resource allocation.

- Proposition 6 – The Blockchain Partners Proposition: Collaboration between the enterprise and external BT partners will lead to successful adoption.

Successful deployment of new technologies in large enterprises requires a high degree of collaboration between all stakeholders involved. This is especially true of BT, which requires the participation of a variety of different actors, including experts in and outside of the enterprise, solution providers, core infrastructure providers, and end-users. The case study results suggest that a high degree of collaboration between enterprises and their technology partners across all cases indicates the importance of having a collaborative mindset and the willingness to co-create solutions in the rapidly evolving blockchain ecosystem. One way to facilitate a strengthened collaboration is to leverage solution providers and other blockchain stakeholders as early as the knowledge phase in the BT adoption journey. This can help enterprises and key decision-makers develop a better understanding of the potential advantages and opportunities the technology offers, leading to a clearer picture of its value to the enterprise. Strong collaboration between internal and external stakeholders facilitates a shared vision of potential use cases. When working closely together, this vision develops into an appropriate solution design based on enterprise and user requirements and creates a strong foundation for the ongoing adoption and use of BT. Several conflicts of scope and ways of working were uncovered during the enterprise failure process. The enterprise was surprised by scope accountability that was not discussed prior to the start of the project. In addition, one consulting partner was viewed as highly focused on selling additional services during the duration of the project, creating distraction and frustration for enterprise stakeholders.

BT presents unique characteristics rarely seen across technologies. The most evident trait is creating a trustless environment for an ecosystem of stakeholders who cannot inherently fully trust each other. Given this context, while there can be value for single organizational use cases to capture efficiencies, such as a global conglomerate, the vast majority of use cases rely on two or more enterprises to adopt a BT-based solution. Innovation adoption is difficult within one large enterprise, therefore successful adoption in an ecosystem of enterprises exponentially increases this difficulty. The propositions presented highlight critical areas that lead to an ecosystem technology to be adopted. Some propositions, such as User Experience and C-Suite Sponsorship, can be addressed during the planning and execution of the BT adoption process. However, propositions such as the Innovation and Partners proposition generally require evidence of fulfillment prior to going down the adoption journey. These insights can help guide future research and inform enterprise decision-makers considering blockchain adoption. While some of our findings align with prior technology adoption research, others offer a nuanced perspective, emphasizing distinctive characteristics and challenges associated with enterprises seeking to adopt BT.

Practical Implications

The propositions provide some guidelines for the practice of BT design, development, and implementation. The Blockchain User Experience proposition suggests that a driver of design and development should be to make the user interface simple, despite the complexity of the underlying blockchain-based engine that powers these applications. User experience optimization can be achieved through careful and well thought out design of the interface, taking into account the needs and preferences of end users. The development process should include clear activities that solicit end-user preferences and requirements, such as the AGILE technology development process. In AGILE, developers use an iterative approach to solution development that builds products in small, digestible increments, collecting and embedding user feedback along the way.

A user interface should be easy to use and minimize the number of clicks or steps to streamline the user experience. Additionally, hard-to-grasp concepts should be communicated in simple, plain language instead of being presented as highly technical concepts. If possible, creating a blockchain solution application that allows users to achieve the value of BT without having to engage with the blockchain is ideal. Training should be provided for existing users to help them transition to the new system and be designed to accelerate competency while balancing training material complexity to generate competency.

Regarding the Blockchain Trilemma proposition, there are several efforts underway to address the blockchain trilemma in the Ethereum ecosystem. One of the biggest changes has been to transition the consensus mechanism from PoW to PoS. The goal of this change was to maintain decentralization while improving scalability and security through lower barriers to entry. PoS randomly selects validators to confirm transactions and create new blocks resulting in reduced hardware requirements to run. Security is improved by creating increased economic penalties for 51% attacks by the investment required to acquire a majority token stake but also the loss of overall token value through a 51% attack. Multiple layer 2 solutions, such as Polygon and Arbitrum, create a scalable environment for solutions through batch transaction additions to the Ethereum blockchain.

Finally, security is enhanced through data privacy innovations such as EY Nightfall. EY Nightfall is an open-source initiative by consulting firm EY that leverages zero-knowledge proofs (ZKPs) by allowing transactions to be verified without revealing the details of the transaction. The transition of Ethereum from PoW to PoS introduces unique implications for developers and businesses. This necessitates developers to upgrade their DApps or smart contracts to the new network, which could involve additional costs and complexity. The usage of layer 2 solutions and zero-knowledge proofs also adds another layer of requisite knowledge and skills. However, these changes also present risks, such as potential centralization with PoS and privacy issues with ZKPs. Therefore, understanding these trade-offs is critical in navigating the trade-offs between decentralization, scalability, and security, which will help materialize the Blockchain Trilemma Proposition at the lower layer protocols.

Regarding the Blockchain Innovation proposition, when enterprise leaders prioritize investment in innovation, they are likely to create a culture that fosters creativity, experimentation, and learning. This is particularly applicable for BT because an innovative organizational culture can be invaluable when exploring the potential applications of BT as it encourages employees to test the technology despite contradictory public narratives around cryptocurrency and the sustainability of the domain. As a result, enterprises are more likely to identify use cases for BT that align with their strategic objectives and drive value for their enterprises. The proposition highlights the necessity of structures and processes to cultivate innovation. Practical measures might include setting up innovation labs, providing blockchain-focused training, forging partnerships with blockchain startups or consortia, and incorporating blockchain into existing digital transformation strategies.

Blockchain adoption mandates alterations in business processes and practices, even when integrated into existing enterprise technologies. Business process change necessitates robust change management to ensure required behavior change from end users and information systems resources. This should include clearly communicating the benefits and reasoning behind the change to all stakeholders, providing ample training and support, managing any resistance, and aligning this change with the organization's culture and strategic goals. A deliberate focus on these aspects can significantly smooth the transition to BT.

Conclusions

The cross-case analysis highlights the importance of compatibility, relative advantage, and observability as strong technological success factors for the continued use of BT applications. Organizational context and knowledge were strong organizational factors, with regulatory compliance as a strong environmental factor. On the other hand, complexity, trialability, communication, and environmental factors (support and trust) emerged as moderate success factors. Further research is necessary to better substantiate these findings. Nevertheless, these findings offer valuable insights into the factors that influence enterprise adoption of BT with continued use and can inform decision-making for enterprises considering blockchain implementation.

While this study offers valuable insights into the factors influencing enterprise adoption of BT, I acknowledge some limitations and identify future research directions to advance the understanding of blockchain adoption in different contexts. First, on the generalizability of the findings given that it is based on only five enterprise cases, the study provides directional insights but may not adequately capture the diverse range of factors influencing BT adoption across different industries, organization sizes, and enterprise cultural contexts. However, given the scarcity of continued use of BT applications, the study provides a rich set of findings that advance the study of BT adoption

Second, this study is limited to BT adoption in larger corporations. Future research can take several directions to expand understanding of enterprise blockchain adoption, for example by collecting data on a more diverse sample of enterprises across various industries, sizes, and cultural contexts. Future research can also address the impact on the continued use of BT of contextual factors, such as industry-specific regulations, competitive dynamics, and technological infrastructures. This can help identify the unique challenges and opportunities faced by enterprises in different sectors, enabling a more tailored approach to blockchain adoption strategies.

Third, this study is limited to some of the few cases of continued BT adoption as of the time of data collection. Therefore, it could be premature to make hard conclusions about what the success factors are, although this study of successful BT adoption is a positive step in this direction. Longitudinal studies could assess the evolution of blockchain adoption factors over time. As the technology matures, additional BT innovations will be developed and more enterprises will effectively appropriate the value that BT offers. This could identify trends and shifts in the importance of different factors and provide insights into the long-term success and sustainability of various blockchain solutions.

Finally, there may be success factors not covered in the interviews. In particular, the TOE framework is at the organizational level, so individual-level success factors were not studied in detail. Researchers could explore the role of individual characteristics, such as employee attitudes, knowledge, and skills, in shaping blockchain adoption. It will be interesting to complement this study with one that addresses the micro-level factors that contribute to the success or failure of blockchain implementation efforts, which can lead to the development of targeted interventions and training programs to support successful BT adoption.

While this study provides valuable insights into the factors influencing early enterprise adoption of BT, further research is needed to refine and expand our understanding of this complex, rapidly evolving domain. By addressing the limitations of the present study and pursuing the identified research directions, scholars and practitioners alike can contribute to the advancement of knowledge in the field of BT adoption.

CHAPTER 5: CONCLUSIONS AND IMPLICATIONS

Implications for Advancing Theory

The results of this study have several implications to build upon and advance various theories in the context of technology adoption and information systems domains. In particular, the study contributes contextual nuances to the TOE framework, DOI theory, and network theory by examining the intersection of BT design characteristics, use case characteristics, and success factors for early enterprise adoption of BT.

With regards to the TOE framework, the research not only provides a holistic view of the multi-dimensional factors influencing the adoption of BT but also reveals specific insights within a BT context, emphasizing distinctive technology characteristics such as decentralization, transparency, and immutability. Insights relating to compatibility and complexity align well with the existing TOE framework literature, indicating that factors impacting BT adoption share similarities with other technologies. Blockchain represents an ecosystem technology. This research validates the need for the TOE framework to be enhanced with inter-organizational considerations to increase understanding of adoption factors whenever the technology is used across organizations. The resulting TOEI model, which includes inter-organizational constructs such as power and trust dynamics across ecosystem stakeholders, should be considered for any technology adoption research that requires an organization to engage and influence beyond organizational boundaries.

This research also builds upon the DOI theory by exploring factors such as compatibility, relative advantage, and observability in the BT context. Although these factors were reaffirmed as predictors of new technology adoption, the research uncovered unique aspects particular to BT adoption, such as the need to prioritize user experience by minimizing exposure to the complexity of the technology and the importance of secure and scalable solutions in the face of trade-offs inherent in blockchain systems.

This research contributes to network theory by examining BT adoption factors through an inter-organizational lens. BT involves collaboration and coordination across stakeholders within an ecosystem and understanding underlying network dynamics is important to the success of BT use case implementations. The case studies provide valuable insights into the role of trust, cooperation, and strategic alignment in fostering sustained BT adoption. Social network theory examines the relationships between actors in a system and how the structure of these relationships influences various outcomes, including knowledge sharing, collaboration, and innovation (Liu et al., 2017). Implications of this research on social network theory include early insights into how network structures, such as centrality or density, impact the likelihood of BT adoption, and the role that social ties between enterprises play to facilitate the spread of knowledge and expertise about BT.

Actor-Network Theory (ANT) is a theoretical approach that considers both human and non-human (e.g., technological) actors as part of a network collectively constructed through negotiation and interaction (Creswell et al., 2010). In the context of BT adoption, ANT highlights the process of negotiating and enrolling different actors (e.g., organizations, individuals, technologies) to adopt and implement BT. Implications of this research for ANT include examining how the process of network formation around BT influences the adoption decision and the challenges faced during the adoption process, including standardization, regulatory compliance, and interoperability.

In summary, this research has meaningful implications for advancing various foundational theories in the context of BT adoption within the information systems domain.

Additionally, this work lays the groundwork for future research seeking to refine existing theories or develop new ones to address the unique challenges and opportunities presented by BT. Building upon and extending these theories can enable researchers to develop a more comprehensive understanding of the factors that drive the successful and continued adoption of BT in enterprises across industries and around the world.

Implications for Business Practice

This research can significantly impact business practice by offering valuable insights for enterprises seeking to explore, adopt, and implement BT with their ecosystem partners. Holistically examining factors that contribute to the successful adoption of BT sheds light on the essential aspects an enterprise needs to consider while concurrently navigating the complex and rapidly evolving BT landscape, ultimately improving success rates in harnessing the transformative potential of this nascent technology. The proposed taxonomy matrix, which analyzes and matches BT design characteristics with specific enterprise use case characteristics, provides a structured framework to guide informed decision-making for organizations exploring BT. This taxonomy matrix can serve as a valuable tool, assisting in optimal design choices aligning with specific requirements and desired outcomes of an enterprise use case.

This research introduces notable implications across organizational management and product development. First, the findings highlight the importance of prioritizing user experience and ensuring compatibility of BT solutions with existing systems and processes. This insight suggests that enterprises should focus on seamless technology integration and prioritizing user-friendly interfaces, therefore minimizing any learning curve for end-users and maximizing the potential for adoption. Additionally, this research showcases the importance of fostering a culture of innovation within organizations. Sponsorship for such innovation should come from top executives to strengthen organizational resolve to pursue solutions like BT. Enterprises should cultivate an open-minded, collaborative environment which encourages employees to explore new ideas, take risks, and embrace emerging technologies such as BT. Promoting this innovation mindset is particularly important when navigating the BT domain, where continued design advances and a highly dynamic regulatory and economic environment demand an adaptable and resilient workforce. An innovation-driven organization is better suited to identify areas in which BT can bring substantial benefits and is more likely to achieve successful implementation and integration of blockchain solutions.

From an enterprise technology perspective, this research highlights the importance of striking a balance between security, scalability, and decentralization when adopting BT. Enterprises must carefully consider the trade-offs between these benefits to deliver robust and reliable solutions that cater to their unique requirements, while also realizing use case value propositions. In many cases, prioritizing security and scalability over decentralization may be the most appropriate approach, as it helps to ensure the integrity of the system while providing the necessary room for solution growth and expansion. Understanding these trade-offs is critical for organizations to develop strategies that align with their business objectives and mitigate potential risks associated with BT implementation.

Finally, the research findings introduce implications for inter-organizational collaboration. The majority of BT use cases for enterprise entails leveraging existing ecosystems or forging partnerships and alliances to drive value creation. Enterprises should actively seek collaborative opportunities that allow them to leverage shared resources, knowledge, and expertise. Establishing strong relationships with external stakeholders, such as technology partners, regulatory bodies, and industry consortia can help organizations navigate the challenges associated with BT adoption and foster successful outcomes for all parties involved.

In summary, this research has generated several implications for business practice, offering a deeper understanding of the factors influencing successful BT adoption within an enterprise context. Enterprises considering the insights gleaned from this study can develop informed strategies and make effective decisions in the design, development, and implementation of BT solutions. This enables organizations to capitalize on the transformative potential of BT, driving value creation internally and across ecosystem stakeholders.

Limitations and Recommendations for Future Research

Despite the valuable insights gained from this study, certain limitations need to be acknowledged and addressed in future research agendas. The use of five enterprise cases may limit the generalizability of the findings, as the study sample may not comprehensively represent the full range of factors influencing BT adoption and continued use across different industries, organization sizes, and enterprise cultural contexts. Although the case study approach is appropriate for generating exploratory insights, expanding the sample size to include a wider variety of enterprises could provide a more robust evidence base for understanding the factors driving successful BT adoption. Additionally, the use of thematic analysis and cross-case comparisons may have led to some factors appearing more prominently than they would in a larger sample. To address this limitation, future research could employ alternative methodologies, such as large-scale surveys or econometric analyses, to identify success factors across a larger sample of organizations and industries.

The focus of my research on large enterprises may limit the applicability of the findings to SMBs, which may face unique challenges and opportunities when seeking to adopt BT. Future research can explore the adoption of BT in SMBs, examining whether the success factors identified hold true for smaller organizations and identifying any additional factors that may be relevant in this context.

While the factors identified provide a comprehensive overview of the potential drivers of successful blockchain adoption, additional factors not covered in the interviews may also be relevant. The use of the TOE framework as the primary lens for categorizing factors influencing blockchain adoption could have led to an oversimplification of the factors at play. While this framework is widely recognized and has been proven effective in technology adoption research, it may not fully capture the intricacies and complexities of blockchain adoption. Adding an individual-level perspective to the research, by exploring factors such as employee attitudes, knowledge, and skills, could provide a more comprehensive view of the adoption process. Future research can employ other theoretical frameworks (e.g., the socio-technical systems approach, the TOEI framework) to explore the impact of individual characteristics on blockchain adoption and continued use, complementing the organizational-level analysis conducted in this study.

The rapid pace of innovation in the BT domain may result in new protocols, techniques, and solutions that could affect the relevance and applicability of the proposed taxonomy. Future research should incorporate these advancements to ensure the taxonomy remains up-to-date and reflective of the current state of the art. Additionally, further research can examine the nuances, trade-offs, or synergies between various BT design characteristics in greater detail, providing more concrete and granular understanding of the real-world implications for enterprise BT applications.

This research agenda primarily focused on the factors influencing blockchain adoption at a specific point in time. As BT continues to evolve and mature, new challenges and opportunities in how individuals and enterprises continue to adopt BT may arise, which were not covered. To address this limitation, future research can employ a longitudinal approach, examining the evolution of BT adoption factors over time. This could help identify trends and shifts in the importance of different factors, providing valuable insights into the long-term success and sustainability of various blockchain solutions.

Future research can also focus on specific use cases both within and across industries. A comparison of adoption factors of a use case across different ecosystems within the same industry can be a compelling agenda as well. Supply chain traceability is a first mover for many enterprise BT use cases due to the natural end-to-end product ecosystem required for consumer goods. However, other highly valuable use cases should see increased adoption in the coming years. One such use case is that of complex inter-organizational contracts which can be automated to minimize human errors in the procure-to-pay process as well as improve capital flows and cash management. Another use case seeing increased adoption recently is the enterprise use of NFTs across a variety of applications, including consumer gamification and intellectual property management.

Overall, this research provides a valuable starting point to understand the factors influencing enterprise adoption with continued use of BT. By addressing the limitations and potential research directions identified, scholars and practitioners can contribute to a more comprehensive understanding of BT adoption which can, in turn, inform better decision-making and implementation for organizations exploring this innovative technology.

Conclusion

The motivation of this research stemmed from my intense curiosity about the nascent, yet transformative, domain of BT and the desire to explore, understand, and address the complexities and challenges that emerge in the process of BT adoption within large enterprises. I am passionate about the potential of BT to revolutionize industries and create a more trustworthy and transparent world. We are witnessing an evolving global business environment, where country and enterprise-level relationships and alliances are changing, resulting in the evolution of trust dynamics within business ecosystems and consumers. BT provides the promise to provide a trustless solution of business data regardless of border or value chain activity.

Through the development of a comprehensive taxonomy matrix of enterprise blockchain design and use case characteristics, this research significantly contributes to the growing body of knowledge on enterprise BT adoption beyond mere use case proof of concept exploration. Systematically evaluating success factors influencing enterprise BT adoption with continued use provides valuable insights for practitioners to understand and navigate the intricacies of the blockchain landscape and make more informed decisions about the development, implementation, and management of BT solutions.

My hope is that this research will demystify BT to practitioners on what it is and how the value proposition spans beyond cryptocurrency as a use case. The case study findings shed light on the crucial role of compatibility, relative advantage, observability, organizational context and knowledge, and environmental factors such as regulatory compliance in the successful adoption and continued use of BT. In addition, the research highlights the importance of user experience optimization, complementing existing systems, prioritizing security and scalability over decentralization, organizational innovativeness, executive sponsorship, and strong collaboration with BT partners. This research has potential to make a meaningful impact in the real world by guiding and informing enterprise decision-makers looking to the value propositions of BT. Not only does this research provide tangible benefits for businesses looking to harness BT, but it paves the way for future research and innovation across various industries and contexts.

I purposely neglected to take a stance regarding on-going macro debates in the BT domain in how the research agenda was designed and executed. For instance, there are two BT practitioner camps with respect to the future landscape of Layer 1 protocols. One side predicts Ethereum will be the only base protocol (outside Bitcoin for its financial transactions purpose) with any shortcomings supplemented through a variety of Layer 2 solutions. The other side predicts Ethereum will be one of several Layer 1 protocols which are connected through bridges and oracles. I believe it is early to put a stake in the ground on one side. However, I lean towards the former through the simple and undeniable fact that Ethereum has the vast majority of BT investment and resource allocation to scale and improve the protocol and ecosystem. However, early research on the adoption of BT can take a neutral position until further levels of adoption are seen over time.

As I reflect on the journey of conducting this research, I am grateful for the opportunities it provided to deepen my understanding of BT and its potential to drive change and innovation in enterprises across the globe. Early in this journey I was introduced to the concept of Ikigai, which is a method to find one’s purpose. I believe this expertise in BT fulfills completely my Ikigai. I am hopeful that the findings of this study will inspire future research and contribute to the advancement of knowledge and practice in the field of enterprise BT adoption, ultimately serving as a catalyst for organizations to unlock the transformative power of this emerging technology.

REFERENCES

Allen, J. D., Towne, S. D., Maxwell, A. E., DiMartino, L., Leyva, B., Bowen, D. J., ... & Weiner, B. J. (2017). Measures of organizational characteristics associated with adoption and/or implementation of innovations: a systematic review. *BMC Health Services Research*, *17*, 1-10.

Atik, J., & Gerro, G. (2018). Hard forks on the Bitcoin blockchain: reversible exit, continuing voice. *Stanford Journal of Blockchain Law & Policy*, 1, 24-41.

Avdzha, A. K. (2017). The coming age of blockchain technology in corporate governance. Tilburg University, Master Thesis. *1*(11), 1-83.

Bailey, K. (1994). Typologies and Taxonomies – An Introduction to Classification Techniques. Sage.

Chwelos, P., Benbasat, I., & Dexter, A. (2000). Research Report: Empirical Test of an EDI Adoption Model. *Information Systems Research*, 12(3), 304-321.

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.

Castro, M., & Liskov, B. (1999). Practical Byzantine Fault Tolerance. *Operating Systems Design and Implementation*, *99*, 173–186.

Chen, L., Cong, L. W., & Xiao, Y. (2021). A brief introduction to blockchain economics. In *Information for Efficient Decision Making: Big Data, Blockchain and Relevance,* 1-40, World Scientific Publishing Company.

Chesbrough, H. W. (2003). *Open innovation: The new imperative for creating and profiting from technology*. Harvard Business Press.

Creswell, J. W., & Creswell, J. D. (2017). *Research design: Qualitative, quantitative, and mixed methods approaches*. Sage publications.

Dalio, R. (2020). *The changing world order: Why nations succeed and fail*. Avid Reader Press.

De Meijer, C. R.W. (2020). Remaining Challenges of Blockchain Adoption and Possible Solutions. https://www.finextra.com/blogposting/18496/remaining-challenges-of-blockchain-adoption-and-possible-solutions.

Dede, S., Köseoglu, M. Can, & H. Yercan, F. (2021). Learning from Early Adopters of Blockchain Technology: A Systematic Review of Supply Chain Case Studies. *Technology Innovation Management Review*, *11*(6), 19-31. http://doi.org/10.22215/timreview/1447

Dubois, A., & Gadde, L. E. (2002). Systematic combining: an abductive approach to case research. *Journal of Business Research*, 55(7), 553-560.

Easton, G., Lundgren, A. (1992). Changes in industrial networks as flow through nodes. In Industrial Networks ~ A New View of Reality, Axelsson, B. and Easton G. (Eds.). pp. 88-104. Routledge.

Edmondson, A. C., & McManus, S. E. (2007). Methodological fit in management field research. *Academy of Management Review*, *32*(4), 1246-1264.

Eisenhardt, K. M. (1989). Building theories from case study research. *Academy of Management Review*, *14*(4), 532-550.

El Salvador's Bitcoin Bet Is Working, Finance Minister Says. (2022, July 28). Bloomberg. https://www.bloomberg.com/news/articles/2022-07-28/el-salvador-s-bitcoin-bet-is-working-finance-minister-says

Essentia. (2019, December 15). *50+ examples of how blockchains are taking over the world*. Medium. https://medium.com/@essentia1/50-examples-of-how-blockchains-are-taking-over-the-world-4276bf488a4b

Evans-Greenwood, P., Hillard, R., Harper, I., & Williams, P. (2016). Bitcoin, Blockchain & distributed ledgers: Caught between promise and reality. *Deloitte.*

Haber, S., & Stornetta, W.S. (1991). How to time-stamp a digital document. *Journal of Cryptology*, *3*, 99–111.

Hakansson, H. (1989). Corporate Technological Behavior: Cooperation and Networks. Routledge Keegan & Paul.

Hakansson, H., & Johanson, J. (1985). A model of industrial networks. *Working Paper*, Department of Business Administration, University of Uppsala.

Hameed, M. A., Counsell, S., & Swift, S. (2012). A meta-analysis of relationships between organizational characteristics and IT innovation adoption in enterprises. *Information & Management*, *49*(5), 218-232.

Hodkinson, P., & Hodkinson, H. (2001, December). The strengths and limitations of case study research. In *Learning and skills development agency conference at Cambridge* (Vol. 1, No. 1, pp. 5-7). University of Leeds.

Huang, Z., Janz, B. D., & Frolick, M. N. (2008). A comprehensive examination of Internet-EDI adoption. *Information Systems Management*, *25*(3), 273-286.

Iivari, J., Hirschheim, R., & Klein, H. K. (1998). A paradigmatic analysis contrasting information systems development approaches and methodologies. *Information Systems Research*, *9*(2), 164-193.

Jeyaraj, A., Rottman, J. W., & Lacity, M. C. (2006). A review of the predictors, linkages, and biases in IT innovation adoption research. *Journal of Information Technology*, *21*(1), 1-23.

Labazova, O., Dehling, T., & Sunyaev, A. (2019, January). From hype to reality: A taxonomy of blockchain applications. In *Proceedings of the 52nd Hawaii International Conference on System Sciences (HICSS 2019)*.

Lacity, M.C. (2018). Addressing key challenges to making enterprise blockchain applications a reality. *MIS Quarterly Executive*, *17*, 201-222.

Lacity, M., Willcocks, L., & Gozman, D. (2021). Influencing information systems practice: The action principles approach applied to robotic process and cognitive automation. *Journal of Information Technology*, *36*(3), 216-240.

Lee, G., & Xia, W. (2006). Organizational size and IT innovation adoption: A meta-analysis. *Information & Management*, *43*(8), 975-985.

Leible, S., Schlager, S., Schubotz, M., & Gipp, B. (2019). A review on blockchain technology and blockchain projects fostering open science. *Frontiers in Blockchain*, *2*(16).

Malone, T. W., Yates, J., & Benjamin, R. I. (1987). Electronic markets and electronic hierarchies. *Communications of the ACM*, *30*(6), 484-497.

Metcalf, B. (1995). Predicting the Internet's Catastrophic Collapse and Ghost Sites Galore in 1996. *InfoWorld.*

Mougayar, W., & Buterin, V. (2016). *The business blockchain: Promise, practice, and application of the next internet technology*. John Wiley & Sons.

Nakamoto, S. (2009). Bitcoin: A Peer-to-Peer Electronic Cash System. http://bitcoin.org/bitcoin.pdf

Nickerson, R. C., Varshney, U., & Muntermann, J. (2013). A method for taxonomy development and its application in information systems. *European Journal of Information Systems*, *22*(3), 336-359.

O'Dair, M. (2018). *Distributed creativity: How blockchain technology will transform the creative economy*. Springer.

Oliveira, T., & Martins, M. F. (2011). Literature review of information technology adoption models at firm level. *Electronic Journal of Information Systems Evaluation*, *14*(1), 110-1213.

Omair, B., & Alturki, A. (2020a). An Improved Method for Taxonomy Development in Information Systems. *International Journal of Advanced Computer Science and Applications*, *11*(4), 535-540.

Omair, B., & Alturki, A. (2020b). Taxonomy of fraud detection metrics for business processes. *IEEE Access*, *8*, 71364-71377.

Pawczuk, L., Massey, R., & Holdowsky, J. (2019). *Deloitte's 2019 Global Blockchain Survey – Blockchain gets down to business*. *Deloitte Insights*, 2–48. https://www2.deloitte.com/content/dam/insights/us/articles/2019-global-blockchainsurvey/DI_2019-global-blockchain-survey.pdf

Rad M., Nilashi, M. & Mohamed, H. (2018). Information technology adoption: a review of the Literature and classification. *Univ Access Inf Soc, 17*, 361–390. https://doi.org/10.1007/s10209-017-0534-z

Ridder, H. G. (2017). The theory contribution of case study research designs. *Business Research*, 10(2), 281-305.

Risius, M., & Spohrer, K. (2017). A blockchain research framework: What we (don't) know, where we go from here, and how we will get there. *Business & Information Systems Engineering*, *59*, 385-409.

Rogers, E. M. (1995). Diffusion of Innovations: modifications of a model for telecommunications. *Die diffusion von innovationen in der telekommunikation*, 25-38.

Rogers, E. M. (2003). Diffusion networks. *Networks in the Knowledge Economy*, 130-179.

Sanka, A. I., Irfan, M., Huang, I., & Cheung, R. C. (2021). A survey of breakthrough in blockchain technology: Adoptions, applications, challenges and future research. *Computer Communications*, *169*, 179-201.

Singer, J., (2022). Ecosystem Centered Market Strategy. https://www.bluespoonconsulting.com/ecosystemcentered-market-strategy-1

Smith, B. (2008). Ontology, in The Blackwell Guide to the Philosophy of Computing and Information.

Tasca, P. & Tessone, C. (2019). A Taxonomy of Blockchain Technologies: Principles of Identification and Classification. *Ledger*, *4*.

Treiblmaier, H. (2018). The impact of the blockchain on the supply chain: a theory-based research framework and a call for action. *Supply Chain Management: An International Journal*, *23*(6), 545-559.

Treiblmaier, H. (2019). Toward More Rigorous Blockchain Research: Recommendations for Writing Blockchain Case Studies. *Frontiers in Blockchain*, 2(3), 1-15.

Van Pelt, R., Jansen, S., Baars, D., & Overbeek S. (2021) Defining Blockchain Governance: A Framework for Analysis and Comparison, *Information Systems Management*, 38(1), 21-41.

Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. *MIS Quarterly*, 425-478.

Walsh, C., OReilly, P., Gleasure, R., Feller, J., Li, S., & Cristoforo, J. (2016). New kid on the block: a strategic archetypes approach to understanding the Blockchain. Presented at the 37th International Conference on Information Systems, Dublin 2016.

Yin, R. K. (2017). *Case study research and applications: Design and methods*. SAGE publications.

Zhao, J.L., Fan, S. & Yan, J. (2016). Overview of business innovations and research opportunities
in blockchain and introduction to the special issue. *Financial Innovation, 2*(28), 1-7.

Zhu, K., Kraemer, K. L., Gurbaxani, V., & Xu, S. X. (2006). Migration to open-standard interorganizational systems: network effects, switching costs, and path dependency. *Mis Quarterly*, 515-539.

Zhu, K., Kraemer, K. L., & Xu, S. (2006). The process of innovation assimilation by firms in different countries: A technology diffusion perspective on e-business. Management Science, *52*(10), 1557-15766.

APPENDIX A: IRB APPROVAL LETTER

Pepperdine University
24255 Pacific Coast Highway
Malibu, CA 90263
TEL: 310-506-4000

NOTICE OF APPROVAL FOR HUMAN RESEARCH

Date: September 14, 2022

Protocol Investigator Name: Matthew Foster

Protocol #: 22-08-1901

Project Title: Factors Driving Enterprise Adoption of Blockchain Technology

School: Graziadio School of Business and Management

Dear Matthew Foster:

Thank you for submitting your application for exempt review to Pepperdine University's Institutional Review Board (IRB). We appreciate the work you have done on your proposal. The IRB has reviewed your submitted IRB application and all ancillary materials. Upon review, the IRB has determined that the above entitled project meets the requirements for exemption under the federal regulations 45 CFR 46.101 that govern the protections of human subjects.

Your research must be conducted according to the proposal that was submitted to the IRB. If changes to the approved protocol occur, a revised protocol must be reviewed and approved by the IRB before implementation. For any proposed changes in your research protocol, please submit an amendment to the IRB. Since your study falls under exemption, there is no requirement for continuing IRB review of your project. Please be aware that changes to your protocol may prevent the research from qualifying for exemption from 45 CFR 46.101 and require submission of a new IRB application or other materials to the IRB.

A goal of the IRB is to prevent negative occurrences during any research study. However, despite the best intent, unforeseen circumstances or events may arise during the research. If an unexpected situation or adverse event happens during your investigation, please notify the IRB as soon as possible. We will ask for a complete written explanation of the event and your written response. Other actions also may be required depending on the nature of the event. Details regarding the timeframe in which adverse events must be reported to the IRB and documenting the adverse event can be found in the *Pepperdine University Protection of Human Participants in Research: Policies and Procedures Manual* at community.pepperdine.edu/irb.

Please refer to the protocol number denoted above in all communication or correspondence related to your application and this approval. Should you have additional questions or require clarification of the contents of this letter, please contact the IRB Office. On behalf of the IRB, I wish you success in this scholarly pursuit.

Sincerely,

Judy Ho, Ph.D., IRB Chair

cc: Mrs. Katy Carr, Assistant Provost for Research

APPENDIX B: SEMI-STRUCTURED INTERVIEW GUIDE

General Questions

1) Please describe the use case for using blockchain technology

2) How did the organization come to use blockchain technology for this use case?

3) How did you determine blockchain design selected for use case?

4) Which characteristics of the design selected do you feel are most important to the use case? Do you feel you only partially satisfied some of the use case requirements due to technology design?

5) What kind of information is on the blockchain? Will they be accessible to anyone?

6) What was the importance of user experience in the design process?

7) Was trialability a consideration in the blockchain design selection process?

8) How did you consider unique blockchain technology design criteria, such as participation in on- and off-chain governance?

Organizational

9) Describe how the idea of using blockchain technology developed within your organization. Which executives were key sponsors of the initiative?

10) Through the adoption of blockchain technology, has any change taken place in your organizational structure?

11) Which are the main costs and/or savings you expect to sustain through adoption of blockchain?

12) Do the organizations continue to perceive the application of the blockchain difficult? Are they still leveraging external support now that the use case is in production?

13) Does the organization have any previous experience with network technology, such as EDI?

Environmental

14) How did you, if at all, communicate blockchain adoption to your customers and/or partners?

15) Do you think your customers associate blockchain with positive organizational transformation? Are you planning to carry out marketing/awareness campaigns to explain how blockchain can contribute to a better product and/or customer experience?

16) Have you ever received pressure from any institution to adopt inter-organizational technologies?

17) Do you have any regulatory or compliance concerns with the implementation of blockchain technology? How did organization solve for regulatory uncertainty of holding crypto as required for gas fees for transactions?

18) Have you asked, or do you intend to request incentives from the government to implement the blockchain?

Inter-Organizational

19) What is the relationship between ecosystem partners that implemented the use case?

20) How much trust is there between partners? Is there a mis-balance of power across ecosystem participants?

21) What were the methods of collaboration and governance required to implement blockchain technology in the ecosystem?

Closing

22) Considering the difficulties in blockchain technology adoption, what were the most important success factors and difficulties you overcame to successfully adopt?

23) Why do you think, despite the hype, the blockchain adoption remains limited in larger organizations?

APPENDIX C: TAXONOMY MATRIX EXPLANATION OF SUITABILITY AND UNSUITABILITY COMBINATIONS

The following are short explanations for each of the intersections of unsuitability:

1) Network type - private | asset tracking and ownership: private networks limit data visibility, making them less suitable for transparent asset tracking and ownership applications that require broader access and visibility.
2) Network type - private | decentralized applications (dapps): private networks restrict access, not offering the openness and accessibility desired for decentralized applications (dapps) that aim to serve a wider audience.
3) Network type - private | payment systems: private networks restrict visibility and accessibility, which is not ideal for global payment systems that require extensive access.
4) Network type - private | communication: private blockchains limit participation, making them unsuitable for open communication platforms with public access.
5) Network type - private | decentralization: private networks maintain centralized control over participation, contrasting with the goal of decentralization in blockchain systems.
6) Network type - private | trustlessness: private networks depend on trust in central authorities, which contradicts the trustless nature of decentralized systems.
7) Network type - private | disintermediation: private blockchains maintain intermediaries that control access, conflicting with the goal of disintermediation in removing such intermediaries.
8) Network type - private | micropayments: private networks restrict widespread participation, while micropayments need broader access and fast transaction times.
9) Network type - private | ecosystem: external: private networks limit external access, which prevents seamless communication and collaboration with other organizations.
10) Consensus mechanism - pow | cost reduction: proof of work consumes a significant amount of computational power and energy, making it less suitable for cost reduction.
11) Consensus mechanism - pow | real-time processing: proof of work consensus takes longer for transaction validation and block creation compared to other mechanisms, not ideal for real-time processing.
12) Consensus mechanism - pow | implementation complexity: low: proof of work complexities and resource requirements make low complexity implementations difficult compared to alternative consensus mechanisms.

13) Consensus mechanism - pow | implementation complexity: medium: similar to the low complexity scenario, proof of work resource requirements create a higher barrier for medium complexity implementations.

14) Consensus mechanism - pow | regulatory considerations: high: proof of work can raise regulatory concerns due to its energy consumption and association with potential illicit activities.

15) Data privacy & confidentiality - public data | identity management: identity management requires protecting personal data, whereas public data lacks privacy, making it openly accessible on the blockchain.

16) Data privacy & confidentiality - public data | payment systems: public data may expose sensitive financial information, making it unsuitable for payment systems that require privacy and confidentiality.

17) Data privacy & confidentiality - public data | value proposition: security (sensitive data storage): public data is openly accessible on the blockchain, making it unsuitable to store sensitive and private information that requires a higher level of security.

18) Data privacy & confidentiality - public data | regulatory considerations: high: public data raises concerns for data protection regulations, such as GDPR or CCPA, as it lacks necessary privacy measures.

19) Smart contracts - non-turing complete | decentralized applications (dapps): non-turing complete languages have limited functionality, which is not ideal for versatile decentralized applications (dapps).

20) Smart contracts - non-turing complete | value proposition: automation: non-turing complete languages lack flexibility for automating complex decision-making processes.

21) Smart contracts - non-turing complete | implementation complexity: high: non-turing complete languages cannot handle complex implementations due to their limited capabilities.

22) Scalability & performance - layer 1 scaling (sharding) | communication: sharding may partition data across shards, complicating real-time communication and data retrieval.

23) Scalability & performance - layer 1 scaling (sharding) | value proposition: real-time processing: sharding introduces cross-shard communication complexities, hindering real-time transaction processing.

24) Scalability & performance - layer 1 scaling (sharding) | implementation complexity: low: sharding complexities and resource requirements make low complexity implementations challenging.

25) Interoperability - cross-platform compatibility | integration with existing systems: standalone: standalone applications do not necessitate communication or interaction with other platforms, rendering cross-platform compatibility unnecessary.

26) Identity & access management - role-based access control | application type: identity management: role-based access control oversimplifies access management in identity systems requiring fine-grained control over user attributes.

27) Governance & compliance - on-chain governance | value proposition: trustlessness: on-chain governance centralizes decision-making power, conflicting with the trustless nature of decentralized systems.

28) Governance & compliance - on-chain governance | ecosystem: internal: on-chain governance may expose internal decision-making processes, which might not be desirable in scenarios requiring privacy.

29) Governance & compliance - on-chain governance | regulatory considerations: high: the suitability of on-chain governance for high regulatory considerations varies depending on the specific governance mechanisms and the regulatory environment.

30) Asset & tokenization - native asset | application type: asset tracking and ownership: native assets lack the flexibility needed for representing various types of assets and tracking their ownership.

31) Asset & tokenization - native asset | value proposition: traceability: native assets hinder traceability by not being specifically designed for tracking asset ownership and transfers.

32) Asset & tokenization - native asset | value proposition: auditing: native assets lack auditability features designed for tracking asset ownership and transfers.

33) Data storage & management - on-chain storage | value proposition: cost reduction: on-chain storage increases costs due to its higher resource requirements and data replication on every node.

34) Data storage & management - on-chain storage | implementation complexity: low: on-chain storage complexities and resource requirements make low complexity implementations challenging.

35) Data storage & management - on-chain storage | implementation complexity: medium: on-chain storage complexities and resource requirements make medium complexity implementations challenging.

36) Security - multi-signature transactions | application type: identity management: multi-signature transactions introduce dependency on other parties for simple actions, potentially compromising user privacy and control.

37) Security - multi-signature transactions | application type: payment systems: multi-signature transactions may complicate payment processes, introduce latency, and negatively affect user experience by requiring multiple signatures.

38) Security - multi-signature transactions | application type: communication: multi-signature transactions mandate multiple parties for simple actions, which is impractical and inefficient for real-time communication processes.

1) Application type:
   a) Data Management:
      i) Merkle patricia trees enable efficient and secure data storage, enabling quick verification of data changes.
      ii) Decentralized storage solutions (e.g., ipfs, filecoin) allow for distributed and fault-tolerant storage of large amounts of data.
      iii) Data exchange protocols (e.g., graphql, rest) enable seamless and standardized communication between different systems.

   b) Asset tracking and ownership:
      i) A consortium network provides a controlled and secure environment for sharing asset data among multiple trusted parties.
      ii) Tokenization (e.g., fungible tokens, non-fungible tokens, securitized tokens) allows for digital representation and easy transferability of assets on the blockchain.

   c) Contract Automation:
      i) Turing complete languages offer comprehensive capabilities for creating complex smart contracts.
      ii) Off-chain execution enables efficient processing, reducing network load and costs.
      iii) Oracles provide external data inputs for smart contracts, enhancing their capabilities.
      iv) Privacy-preserving smart contracts ensure sensitive data is protected while retaining functionalities.

   d) Decentralized applications (dapps):
      i) Public networks allow for open access and participation, fostering a diverse ecosystem.
      ii) Turing complete languages enable the creation of versatile and complex dapps.
      iii) Layer 2 scaling (state channels, plasma chains) enhances performance and reduces transaction costs.
      iv) Cross-platform compatibility ensures dapps can interact with various other systems, promoting adoption.

   e) Identity management:
      i) Encrypted data and zero-knowledge proofs ensure sensitive identity information remains confidential while enabling essential transactions.

ii) Decentralized identifiers (DIDs) provide a flexible, self-sovereign approach to identity management.
iii) Attribute-based access control offers flexible access management based on user attributes.

f) Payment systems:
i) Public or consortium networks cater to different trust requirements and governance models.
ii) Proof of stake (PoS) or practical byzantine fault tolerance (PBFT) consensus mechanisms provide efficient and secure validation.
iii) Cross-chain communication enables seamless transactions between different blockchain platforms.
iv) Tokenization (e.g., stablecoins, CBDCs) offers various digital currency options for different use cases.

g) Communication:
i) Public or consortium networks provide various levels of access control and security for communication purposes.
ii) Encrypted data ensures secure communication and protection of sensitive information.
iii) Layer 2 scaling - state channels enable fast and low-cost messaging and communication transactions.

2) Value Proposition:
a) Transparency
i) Public or consortium network type: offers varying degrees of openness and collaboration in data sharing and decision-making.
ii) Public data (openly accessible on the blockchain): enables easier access, sharing, and verification of data among participants.
iii) On-chain auditability: promotes a transparent ledger for easy monitoring and compliance.

b) Security
i) Cryptography: ensures secure communication and data storage through mathematical algorithms.
ii) Multi-signature transactions: reduces the risk of unauthorized transactions by requiring multiple participants to agree.
iii) Hardware security modules (hsm), secure multi-party computation (smpc), key management systems (kms), identity & access control mechanisms: various security solutions that protect sensitive data and ensure authorized access.

c) Decentralization
   i) Public or consortium network type: encourages diverse participation in decision-making processes.
   ii) Consensus mechanism (e.g., proof of stake, delegated proof of stake, federated byzantine agreement): provides decentralized agreement on the state of the ledger.
   iii) Off-chain governance: delegates decision-making power to known participants by allowing them to set rules or policies.

d) Immutability
   i) Consensus mechanism (e.g., proof of work, proof of stake): ensures that the ledger is not easily altered by any single participant.
   ii) Merkle patricia trees: provides a data structure that records a secure, verifiable history of transactions.
   iii) On-chain storage: guarantees that data is securely stored within the blockchain network.

e) Trustlessness
   i) Public network type: eliminates the need for a central authority by distributing decision-making power to all participants.
   ii) Consensus mechanism (e.g., proof of stake, practical byzantine fault tolerance): ensures ledger accuracy without relying on trust between participants.
   iii) Off-chain governance: delegates decision-making power to participants by allowing them to set rules or policies.

f) Automation
   i) Turing complete smart contract language: enables complex logic and automation in transactions.
   ii) Off-chain execution: allows computation to occur off-chain, reducing network congestion and increasing efficiency.
   iii) Oracles: provides real-world data for automated decision-making in smart contracts.
   iv) Secure multi-party computation (smpc): facilitates secure data sharing and computation among multiple parties without revealing private information.

g) Cost reduction
   i) Consensus mechanism (e.g., proof of stake, delegated proof of stake, proof of authority): reduces energy consumption and overall expenses related to maintaining the network.
   ii) Layer 2 scaling solutions: improves network performance and reduces fees associated with transactions.

iii) Off-chain storage (e.g., distributed hash table): minimizes the storage requirements on-chain, lowering costs.

h) Fraud avoidance
   i) Consensus mechanism (e.g., practical byzantine fault tolerance): protects against malicious behavior by requiring coordination across multiple servers.
   ii) Cryptography: ensures secure communication and data storage that can deter fraud.
   iii) Security solutions (e.g., hardware security modules, secure multi-party computation): enhance data protection and trustworthiness, reducing the opportunities for fraud.

i) Traceability
   i) Merkle patricia trees: provides a cryptographic data structure that records a secure, verifiable history of transactions.
   ii) Immutable ledgers: offer a permanent, tamper-resistant ledger than can trace asset history and ownership.
   iii) Non-fungible tokens (nfts), erc-721: enable unique representation and tracking of different assets.

j) Auditing
   i) Merkle patricia trees: provides a cryptographic data structure that records a secure, verifiable history of transactions.
   ii) Data versioning & timestamping: offer a permanent, tamper-resistant ledger that eases auditing and verification processes.
   iii) Regulatory compliance tools (e.g., monitoring, auditing) & identity & access control mechanisms: help ensure adherence to standards and proper access control, simplifying auditing.

k) Real-time processing
   i) Consensus mechanism (e.g., proof of stake, practical byzantine fault tolerance): offer efficient consensus methods that can enable real-time processing.
   ii) Scalability & performance solutions (e.g., layer 2 scaling, state channels, optimistic rollups): enhance network capacity and efficiency, enabling faster transaction processing.

l) Disintermediation
   i) Public network type: provides a decentralized platform that can remove intermediaries and central authorities in transactions.
   ii) Cross-chain communication: facilitates seamless interaction between different blockchain networks, bypassing intermediaries.
   iii) Tokenization: enables the creation and transfer of digital assets without intermediaries.

iv) Security solutions (e.g., multi-signature transactions): offer user-controlled security measures that can reduce reliance on central authorities.

m) Micropayments
   i) Layer 2 scaling solutions (e.g., state channels, lightning network): increase scalability and lower transaction fees, making micropayments more viable.
   ii) Tokenization (e.g., fungible tokens): enables the creation and transfer of digital currencies, simplifying micropayments.
   iii) Cryptography: provides secure and enhanced privacy for low-cost transactions.

n) Legally binding recording and timestamping
   i) Merkle patricia trees: provides a cryptographic data structure that records a secure, verifiable history of transactions.
   ii) Data versioning & timestamping: offer a permanent, tamper-resistant ledger that can serve as legally binding evidence.
   iii) Regulatory compliance tools, identity & access control mechanisms: help ensure adherence to legal standards and proper access control, facilitating legally binding records.

o) Risk decentralization
   i) Decentralized network type: distributes decision-making power, reducing single points of failure.
   ii) Consensus mechanism (e.g., proof of stake, federated byzantine agreement): ensures ledger accuracy without centralizing risk.
   iii) Multi-signature transactions: reduces the risk of unauthorized transactions by requiring multiple participants to agree.

p) Reduction of redundancy
   i) Merkle patricia trees: provides a cryptographic data structure that reduces data redundancy while maintaining secure, verifiable transactions.
   ii) Off-chain storage (e.g., distributed hash table): minimizes on-chain storage requirements, reducing redundancy and maintaining efficiency.
   iii) Decentralized storage solutions (e.g., ipfs, filecoin): store data across multiple nodes, eliminating single points of failure and reducing storage redundancy.

q) Reduction of information asymmetry
   i) Data exchange protocols (e.g., graphql, rest): enable seamless data exchange among participants, reducing information barriers.

ii) Data privacy & confidentiality (e.g., encrypted data, zero-knowledge proofs): protect sensitive information while allowing for controlled data sharing, reducing information asymmetry.
iii) Identity & access control mechanisms: facilitate proper access control, ensuring that participants get the right information based on their roles and attributes.

3) Implementation complexity:
   a) Low
      i) Network type: permissioned public - simplified governance and access control, with reduced overhead compared to fully public networks.
      ii) Network type: private - allows for centralized control, making it easier to manage and maintain the system while maintaining privacy and security.
      iii) Consensus mechanism: proof of authority - offers faster transaction times and lower energy consumption compared to pow and pos, while maintaining network integrity.
      iv) Scalability & performance: layer 2 scaling solutions (e.g., state channels, plasma chains) - enhances the system's capability to handle increasing workloads without impacting the main chain's performance.

   b) Medium
      i) Network type: public - although more complex than private or permissioned networks, public networks offer improved transparency and decentralization.
      ii) Network type: consortium - provides shared governance between multiple parties, enabling collaboration and consensus without excessive complexity.
      iii) Consensus mechanism (e.g., proof of stake, delegated proof of stake) - these mechanisms balance efficiency and decentralization, providing a moderate level of implementation complexity.
      iv) Smart contract language capabilities: turing complete - enables more complex and flexible applications, while slightly increasing the learning curve and implementation challenges.
      v) Layer 2 scaling solutions - provide additional scalability options to cater to growing demands and increased adoption, with a moderate level of implementation effort.

   c) High
      i) Network type: public - requires robust security measures, performance optimization, and a more extensive governance framework, increasing implementation complexity.
      ii) Network type: consortium - combines the challenges of public networks with the requirements of collaboration among multiple parties, necessitating a sophisticated implementation strategy.

iii) Smart contract language capabilities: turing complete - facilitates the development of complex applications and intelligent contracts requiring greater expertise and deployment effort.
iv) Scalability & performance solutions (e.g., layer 1 scaling - sharding, state channels, plasma chains) - these advanced solutions demand significant effort to integrate and optimize, adding challenges to implementation.
v) Advanced security measures (e.g., secure multi-party computation) - implementing cutting-edge security solutions demands a high level of expertise and resources to ensure protection against ever-evolving threats.

4) Ecosystem:
a) Internal
i) Network type: permissioned public - allows for fine-grained control over access and participation within an organization while maintaining transparency and auditability.
ii) Network type: private - offers greater control and privacy, as it's limited to a single organization and its stakeholders, ensuring secure data handling.
iii) Off-chain governance - provides the flexibility to manage and make decisions outside of the blockchain, enabling efficient and tailored governance processes in an internal context.
iv) Regulatory compliance tools (e.g., monitoring, auditing) - tailors compliance efforts to an organization's specific legal and regulatory requirements, ensuring accurate and efficient adherence.

b) External
i) Network type: public - enables borderless and permissionless participation, fostering a truly open network and collaboration in an external ecosystem.
ii) Network type: consortium - facilitates collaboration between multiple organizations, ensuring controlled access and shared governance while maintaining a broader reach in the external ecosystem.
iii) Scalability & performance solutions (e.g., layer 2 scaling - state channels, plasma chains) - adopts performance optimizations for use in an external context, where demands may fluctuate significantly.
iv) Interoperability solutions (e.g., cross-platform compatibility, cross-chain communication, token & asset bridges) - supports seamless interaction and cooperation among diverse blockchain systems across the broader ecosystem.

c) Mixed
i) Network type: consortium - balances the needs of multiple organizations with different internal and external ecosystem requirements, achieving a cooperative infrastructure.

ii) Scalability & performance solutions (e.g., layer 2 scaling - state channels, plasma chains) - ensures a performant system, capable of handling varying workloads from diverse participants in a mixed ecosystem.
iii) Interoperability solutions (e.g., cross-platform compatibility, cross-chain communication, token & asset bridges) - guarantees smooth interactions between internal systems and external networks, enabling seamless integration with other platforms in a mixed ecosystem.

5) Regulatory considerations:
  a) Low
    i) Identity & access management: decentralized identifiers - supports user privacy without the rigidity of a centralized identity verification system.
    ii) Identity & access management: attribute-based access control - simplifies permissions management in organizations with fewer compliance requirements.
    iii) Governance & compliance: off-chain governance - allows flexibility and easier compliance adaptation in environments with minimal regulation.

  b) Medium
    i) Identity & access management: decentralized identifiers - balances user privacy with the need for regulatory adherence by selectively sharing user attributes.
    ii) Identity & access management: attribute-based access control - streamlines permissions management while catering to specific regulatory compliance requirements.
    iii) Governance and compliance: monitoring/auditing - enhances transparency and oversight in adapting to moderate regulation, promoting trust and accountability.

  c) High
    i) Governance and compliance: regulatory compliance - ensures strict adherence to legal and regulatory requirements, including security and privacy policies.
    ii) Governance and compliance: kyc/aml - incorporates know your customer and anti-money laundering procedures to prevent fraud and illicit activities.
    iii) Governance and compliance: personal data (e.g., gdpr, hipaa) - complies with stringent data protection regulations, safeguarding sensitive personal information.

6) Integration with existing systems:
  a) Standalone
    i) Network type: permissioned public - allows for controlled access while maintaining a separate space for blockchain transactions and data.
    ii) Network type: private - isolates the blockchain system from external influences, enabling it to function independently.

iii) Consensus mechanism: proof of authority - facilitates faster and more energy-efficient transaction processing within the standalone ecosystem.

b) Interoperable
   i) Network type: public or consortium - supports shared, standardized protocols, and technologies for collaboration and seamless interactions between networks.
   ii) Interoperability: cross-platform compatibility - enables communication and cooperation among various blockchain systems.
   iii) Interoperability: cross-chain communication - facilitates the exchange of data, assets, and transactions between different blockchain networks.
   iv) Interoperability: token & asset bridges - streamlines the transfer and management of tokens and assets across multiple platforms.
   v) Data storage and management: data exchange protocols (e.g., graphql, rest) - employs widely-adopted protocols for seamless api integration with existing systems.

c) Fully Integrated
   i) Network type: public, network type: consortium - offers an open, collaborative environment that incorporates multiple entities and systems in the integrated ecosystem.
   ii) Interoperability: cross-platform compatibility - establishes a basis for communication and cooperation among various blockchain systems and applications.
   iii) Interoperability: cross-chain communication - facilitates the exchange of data, assets, and transactions between different blockchain networks, merging their capabilities and resources.
   iv) Interoperability: token & asset bridges - streamlines the transfer and management of tokens and assets across multiple platforms.
   v) Identity & access control mechanisms: decentralized identifiers - provides consistent identity management across different platforms, improving user experience and interactions.
   vi) Identity & access control mechanisms: attribute-based access control - streamlines permissions management across different networks and applications, ensuring a seamless integration.
   vii) Data storage and management: data exchange protocols (e.g., graphql, rest) - integrates easily with the existing systems via widely-adopted protocols for apis and data exchange.