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Unriddling Blockchain: A Study of Outcomes, Tensions, and Governance of Blockchain Implementations

PhD Thesis

by

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To my parents
– my eternal source of
strength, inspiration and
love

Faleminderit!

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Introduction

Research Background

Blockchain has been heralded as one of the most disruptive technologies in the last decade (Frizzo-Barker et al., 2020; Pan et al., 2020). The introduction of blockchain has offered a new perspective on distributed systems and has extensively impacted the conventional exchanges of data transmission (Tapscott & Tapscott, 2016). The technology was first introduced as a key pillar of Bitcoin but has since been used as an enabling mechanism for securely recording any transaction (Nofer et al., 2017; Hawlitschek et al., 2018). The technology consists of a distributed digital ledger that registers transactions shared and executed on a particular network based on predefined set of rules. As transactions occur, a copy is registered in the form of "blocks", encrypted through unique "hash" codes, which makes every transaction registered on blockchain transparent, unalterable and irreversible (Pilkington, 2016; Hawlitschek et al., 2018; Ismail & Materwala, 2019)

The blockchain technology has offered an innovative alternative to centralized systems, and many traditional concepts associated with the latter. Blockchain eliminates the need of a middleman as transactions are verified automatically by distributed nodes in a peer-to-peer network, enabling thus the emergence of decentralized systems (Lacity, 2018; Zachariadies et al., 2019). In this regard, blockchain based smart contracts have played a particularly important role in ensuring that pre-determined terms and conditions are automatically executed (Mendling et al., 2018; Wang et al., 2019). Blockchain has thus provided not just a set of new technological features but a social promise for more effective operations, making it particularly important in revolutionizing intrapersonal interchanges (Zachariadies et al., 2019; De Filippi et al., 2020).

Currently, evidence suggests that the adoption of blockchain technology is continuing to progress at a very fast pace and is showing no signs of deceleration. Today, the technology is considered a breakthrough not only in computing environments and distributed systems, but also in various industries in terms of application and use cases (Chen et al., 2018; Abou Jaoude & Saade, 2019; Bodkhe et al., 2020). Developers have been able to experiment with diverse variations of blockchain networks and consensus mechanisms in order to offer technical infrastructures able of addressing different needs (Hawlitschek et al., 2018; Monrat et al.,

2019). As a result, both private and public sectors have witnessed how the distinct features of blockchain have a given rise to a new outlook to creating trustless systems and new business models (Tapscott & Tapscott, 2016; Angelis & Da Silva, 2019).

Blockchain's ability to offer new ways of establishing relations, managing networks and registering exchanges has led to a distinct public interest in the topic. Given its implications, blockchain offers good incentives for both scholars and practitioners alike to continue studying and investigating further the technology in the long run (Beck et al., 2017; Abou Jaoude & Saade, 2019). In this regard, evaluating the true potential of blockchain through rigorous empirical evidence and multidisciplinary perspective remains imperative in assessing the future of the technology (Risius & Spohrer, 2017; Rossi et al., 2019).

Problem Statement

From a theoretical perspective, evidence from scholarly articles suggests how the existing body of research focuses mostly on the architectural aspects related to the technology and therefore, there is a grey area in literature linking blockchain with established theories, frameworks or models (Monrat et al., 2019; Pelt, 2021). Despite blockchain having been in the spotlight for over a decade, there is an ongoing concern on the need to widen the discourse on the topic of blockchain beyond the technical features and performance evaluation (Ølnes et al., 2017; Hughes et al., 2019).

More specifically, in the domain of Information Systems (IS) there has been a continues call to look at blockchain from multidisciplinary approaches in an effort to better interpret the benefits and challenges associated with the technology (Ølnes et al., 2017; Risius & Spohrer, 2017). In this regard, research should dwell further into linking blockchain with different levels of analysis including users, platforms, industries (Risius & Spohrer, 2017) and sociocultural patterns (Ghosh, 2019; Rossi et al., 2019). In this regard, more rigorous empirical studies should center around the unexplored avenues in IS research in order to understand better the implications of blockchain and improve our understanding of the technology (Ghosh, 2019; Lu, 2022).

Furthermore, blockchain has been regarded as a potential technology with a series of important techno-social implications, nevertheless, the technology should not be considered bulletproof. Research has demonstrated that whilst blockchain provides important technological innovations, its adoption can be very challenging (Batubara et al., 2018; Spahiu et al., 2022). In this regard, many studies have underlined how theorizing on such challenges

is still lacking and more empirical investigation is required in order to have a more concrete understanding of the impeding factors (Zheng et al., 2018; Monrat et al., 2019).

Although the number of blockchain applications has exponentially increased, many blockchain initiatives are short lived and more result oriented research on successful case studies is required (Rossi et al., 2019; Treiblmaier, 2020), especially with regard to the role of governance where evaluations have been limited (Beck et al., 2018; Pelt et al., 2021; Lumineau et al., 2021). Lastly, blockchain adoption has not been proportionate in every sector, with public domain and public administration showing particularly low rates of adoption, despite factual evidence displaying blockchain's potential in such areas. In this regard, current studies have only looked at the inherent nature of these domains but make little reference to the potential challenges related to the blockchain attributes (Navadkar et al., 2018; Cagigas et al., 2021).

Research Aims and Objectives

As described in more detail in the previous section, our analysis of the literature on blockchain revealed that there remain various areas where research on the technology appears to be still at a novice stage. Consequently, the aim of the work included in this thesis is to examine blockchain whilst answering the current calls in academia for addressing the aforementioned grey areas concerning the technology. The analysis and investigations conducted in this regard, intend to contribute to Information Systems research by advancing the overall understanding of blockchain through detailed analysis of current findings. In doing so, we put forward the following objectives to be addressed by the three research papers encompassed in this thesis:

Objective 1: *Develop a classification for summarizing emerging patterns resulting from blockchain based applications.*

Given the dispersive nature of blockchain applications, this would allow for a better understanding of the main implications resulting from blockchain adoption. Most of the different categorizations associated with blockchain so far have predominantly focused on the technical characteristics of blockchain. Therefore, the aim is to identify the positive and dismissive implications going beyond the architectural setting associated with the technology

and based on actual projects and implications.

Objective 2: *Offer a multidisciplinary approach to studying the blockchain technology.*

This would enable the opportunity to have a more panoramic view of the technology. In doing so, the work presented in this thesis aims at addressing the need for studying blockchain from an interdisciplinary perspective. Bridging themes stemming from different disciplines would expose the technology to a more comprehensive review. In addition, given the complexity of the technology this would widen the discourse on blockchain and would allow to investigate its potential not only as a technological innovation but also as a social phenomenon.

Objective 3: *Analyze findings stemming from blockchain based applications with established theoretical frameworks in IS research.*

Despite the exponential growth and undivided interests that blockchain has profited from, many aspects of the technology remain undetermined. The research incorporated in this thesis aims at analyzing and interpreting the insights emerging from blockchain and blockchain based applications with specific frameworks and corresponding constructs. Borrowing theoretical constructs would allow to position blockchain around well-established themes and offer alternative conceptual basis for comprehending the technology.

Objective 4: *Investigate how blockchain can be successfully integrated into current infrastructures and practices.*

The aim of this objective is two folds. Given how the adoption rate in some domains remains low, first it would be imperative to understand potential challenges that might hindrance blockchain adoption. Secondly, it would address the current need in literature for showcasing successful blockchain based applications in an effort to understand better the implementation process, especially in terms of governance.

Research Setting

In order to address the four objectives posed in this body of work , the research conducted was based on investigations focusing on the public domain. The motive for looking at examples stemming distinctly from the public domain was to offer a more holistic view regarding blockchain initiatives in a setting where investigations regarding certain aspects remains limited. Consequently, the three chapters of this thesis are based on research concerning the public domain, given also how evidence stemming from extensive literature review revealed that blockchain adoption rate in this area has been particularly low compared to other sectors.

Therefore, the goal for this thesis consisted of empirically inquiring into the challenges potentially preventing adoption and at the same time provide a fresh perspective on the features leading to the successful blockchain implementation from a concrete example in the domain. The first two chapters will provide a classification of the main outcomes of blockchain based initiatives in the public domain, whilst also identifying the main challenges confronted during implementation. The third chapter will showcase a successful blockchain based case study. This last chapter looks at a financial institution pertaining to an intergovernmental organization in an effort to highlight how blockchain implementation was handled and the important elements that lead to a positive outcome.

For the purpose of this research, OECD's definition of "public domain" was adopted. According to this definition, public domain refers to all services that are owned or controlled by the government, in addition to any service which despite being privately owned, are funded by the government or similar authorities (Pilichowski and Turkish, 2018). Public administration (PA) on the other hand, refers to the operational unit of the public domain responsible for implementing the various services pertaining to the aforementioned (Shafritz et al., 2015).

Thesis Outline

The research conducted for this thesis is organized into three chapters, each describing one particular study. A brief description of each study and the most relevant contributions originating from the research is detailed below:

Chapter 1

Beyond Scattered Applications: A Taxonomy of Blockchain Outcomes in the Public Domain

The first chapter focuses on providing a taxonomy of blockchain outcomes in the public domain. Considering how different blockchain based systems and platforms have been adopted by public bodies and governments all around the world as a more effective alternative to delivering various functions, the focus of this chapter will be on the offering a classification of the outcomes deriving from such applications. The study answers the following research question: *"What are the observed dimensions of blockchain initiatives in the public domain?".*

The taxonomy development method follows Nickerson et al., (2013) framework designed for studies concerning particularly Information Systems. The investigation is based on 22 case studies on blockchain applications extracted from 79 records originating from SCOPUS and 13 governmental reports. The final taxonomy of blockchain outcomes emerging from the research consists of 5 dimensions: Use cases, Organizational Extensions, Type of Users, Benefits, Risks and Challenges and Public Value.

Main contributions: Given how taxonomies are considered effective tools for examining complex areas, this research is expected to create an alternative mapping and standardization of information on blockchain-based initiatives, in an attempt to understand the full scale of applicability of blockchain. The fact that the study highlights apart from the positive aspects, the challenges associated with the technology indicates how blockchain is an intricate innovation and requires extra attention in terms of research on particular areas. Eventually, this study offers a comprehensive overview for decision-makers in the sector who may be interested in the technology with regard to the use cases, potential and the expectations risk wise.

Chapter 2

Tensions Affecting Blockchain-based Information Infrastructures in Public Administration

Having looked firsthand through the first study, which included a dimension dedicated to the risks and challenges that are associated with blockchain, the second chapter focuses on dwelling further on identifying the potential issues emerging when adopting the technology in

public administration (PA). The study aims at answering: *"How can blockchain be integrated into PA infrastructures?" by* pinning down the challenges identified in terms of tensions of information infrastructures (II) - given how the principal characteristics of the latter coincide with the main blockchain attributes and properties .

For the purpose of this research 11 interviews were conducted with individual in key positions within the PA in Italy, who had direct involvement or knowledge regarding blockchain adoption. The final results were summarized by adopting and adapting the Ribes and Finholt (2009) framework on tensions. The analysis of the findings resulted in 9 important tensions, which we conclude could be the leading cause for the lack of a wider adoption of the technology in PA.

Main contributions: Given that there is insufficient evidence on the reasons why certain areas such PA appear more hesitant in implementing blockchain, this research offers the opportunity to address such lack of clarity and offer a comprehensive understanding of tensions affecting a wider adoption. In doing so, by focusing on the perspective of II and adopting the Ribes and Finholt (2009) framework, the study addresses the need to look at blockchain through new theoretical lenses. In addition, this research extends the concept of blockchain based IIs as it highlights the similarities between an Information Infrastructure and properties pertaining to blockchain. Moreover, in terms of practical implications, the tensions emerging from the findings highlight how organizational, governmental and cultural aspects that go beyond the technical characteristics of blockchain, can play an important role in blockchain adoption.

Chapter 3

Blockchain and Polycentricity: An Architecture and Governance Perspective

The third chapter aims at exploring the mechanisms behind successful blockchain implementation in light of specific governance models. It does so by addressing the following research questions: "*How can a blockchain based architecture combine successfully with a polycentric governance system?".* Hence, the research presented in this study investigates how the specific architecture behind blockchain and polycentricity as a governance model, interact and shape the successful implementation process of a blockchain-based solution.

The paper is based on extensive interviews conducted with key personas in the financial

institution of an intergovernmental organization that has successfully adopted blockchain as means of digitally transforming one of its most important processes. To explain the relationship emerging from the findings, the research adopts the Architecture-Governance configuration model as articulated by Hanseth and Modol (2021).

Results describe the existence of a symbiotic relationship where polycentric governance - explained in terms of multitude of stakeholders, specific norms and efficient leadership - can play an important role in the implementation of blockchain, whilst the blockchain architecture was found to be equally efficient in tackling the "tragedy of the commons", which polycentricity has frequently aimed at addressing. Eventually, based on such findings a theoretical framework underlying the emerging themes that connect decentralized architecture and polycentric governance systems was constructed.

Main contributions: This research introduces a successful blockchain implementation and the important elements leading to such success. The main implications of this study concern the evolution of digital infrastructures and the importance that the intrinsic relationship between architecture and governance bear in the process. Consequently, on the one hand, this research describes the role that governing structures can have in the successful implementation of emerging technologies. And on the other hand, it recounts how decentralized architectures can aide in addressing the "tragedy of the commons". Finally, by looking at blockchain adjacent to polycentricity, this study addresses the call for more interdisciplinary research in an effort to better understand the full potential of blockchain.

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CHAPTER 1

Beyond Scattered Applications: A Taxonomy of Blockchain Outcomes in the Public Domain [1]

Abstract

As a decentralized digital ledger, blockchain has become a buzzword in the recent years, due to its advantageous characteristics. The application of blockchain has been associated with different implications, ranging from trust generator to increased efficiency. Recently, blockchain application has gained momentum by being implemented by different governments and public bodies, as a solution for tackling different issues, with the intent of providing more efficient public policies. Different blockchain-based systems and platforms have been increasingly introduced, as a more secure and orderly alternative of delivering various public functions and services. Given the wide experimentation of blockchain in the public domain and the scattered information in this regard, by analyzing twenty-two case-studies this paper develops a taxonomy of blockchain outcomes, classifying the emerging patterns and subcategories. The proposed taxonomy can support decision-makers and researchers in considering the various blockchain applications, alongside their benefits, implications, and possible associated risks.

Keywords: Blockchain, Smart Contracts, Distributed Ledger Technology, Digital Transformation, Public Administration, Taxonomy, Data Control, Public Value

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Introduction

Blockchain is a decentralized data management technology that, through a distributed ledger, provides new ways of managing, governing, storing, and distributing information (Iansiti and Lakhami, 2017; SunYin et al, 2019). At the core of blockchain, there is a computer protocol acting as an automatic contract enforcing exchanges between parties by means of irreversible and secure transactions (Cong et al., 2017). Blockchain's novel technology also presents a new way of establishing trust through its different consensus protocols and cryptography that make transactions verifiable and fault tolerant (Beck et al.,2016; Shin, 2019). The advantage of blockchain is that it also has different architectural configurations allowing for better fitting the application of blockchain to different objectives. The different architectural dispositions, such as network access, type of consensus mechanism, data control and network type, offer the opportunity to allow or restrict access while also offering elevated security (Zhang and Lee, 2020).

The current body of knowledge has shifted into disseminating the potential of blockchain into numerous different applications and sectors that go beyond the financial sector and cryptocurrency (Alharby and Moorsel, 2017). The diversity of blockchain applications in terms of scope is not only related to the multi-purpose nature of such technology, but also to various needs. Governments today continue to face the need to be more open and transparent in the eyes of the society (Hollyer et al., 2011). In turn, openness and transparency are considered to be the main components that lead to building strong accountability and trust in a society (Gaventa, 2013; Johnston, 2001). Considering that the root to most of the public policies failure is due to incompetence, corruption, or inefficient governance (Mueller, 2020), this gives reason to explore blockchain as a possible solution to such issues (Hyvärinen, 2017). In fact, blockchain has been adopted in the public domain to enforce existing or new policies through a digital transformation process that offers a rapid accomplishment to multiple societal goals by different governmental bodies (Berryhill, 2018).

Given the dispersive nature of the applications, we find it important to understand the digital transformation rationale behind the adoption of blockchain in public domain, and secondly, to provide a classification of what blockchain outcomes derive from different applications. In this regard, we believe that, under specific conditions, blockchain can be an enabler of digital transformation (Vial, 2019), since it is a technology that creates disruption. Additionally, we agree that digital transformation is more often than ever a byproduct of the

need to address different societal challenges (Majchrzak et al., 2016). By highlighting the value created by digital transformation processes when societal challenges are addressed, we are interested in looking at the blockchain applications in the public domain that demonstrate to have achieved improvements that go beyond the efficiency of a specific service. Therefore, we develop a taxonomy (Nickerson et al., 2013) that answers the following research question: *"What are the observed dimensions of blockchain initiatives in the public domain?"*.

We expect this research to draw various contributions in the study of blockchain. By creating a map of successful applications and the various public functions that blockchain could be taken advantage of, we expect to create a better overview for decision-makers in the sector who may be interested in blockchain adoption or organizations seeking to improve their performances through digital transformation. Also, considering the lack of blockchain studies the process of adoption of this technology, we expect our findings to identify new research perspectives that could pave the way to future studies on blockchain-based systems design and implementation.

Background

Blockchain in the Public domain

In recent years, blockchain has gained popularity in the public domain due to successful implementations ranging from public administration to public policy and from public offices to supporting whole e-government transformation. For the purpose of this study, we incorporate such blockchain applications under the term "public domain". According to OECD, the public domain includes services owned or controlled by the government in addition to services that, despite being private, are funded by the government or similar authorities (Pilichowski and Turkisch, 2018).

As regards the wide range of blockchain applications in public domain, from notary services to voting (Alketbi et al., 2019; European Commission, 2018), an important role has been played by the introduction of smart contracts, a main feature of the blockchain technology, as a guarantor of full automation of process without the need of intermediaries or even human interaction (Qi et al, 2017). A particular area where blockchain has gained momentum is digital government or e-government (Hou, 2018; Terzi et al.,2019). Sobolewski and Allesie (2021) show that Europe in particular has been quick in exploring and pioneering different projects in this regard, but real-life applications have been on the rise even in other countries, such as in

India, China, UK, and Brazil, etc. (Hou, 2017; Ojo and Adebayo, 2017; Deloitte, 2018).

Public administrations as an operational unit in the public domain have proven to be a good basis for the application of blockchain, since the very nature of their practices is based on data certification, traceability, and transparency (Rot et al, 2020), and blockchain does not change the nature of services, rather it is expected to facilitate the way in which they are provided (Casino et al., 2019). Distinctive features such as citizen trust, privacy and record keeping make blockchain a potentially pervasive technology that can be adopted at different levels in public administrations (Carter and Ubacht, 2014). Subsequently, studies have gone so far as to look at blockchain as the initiator of new governance models in the public administration (Olnes, 2016; Hou, 2017; Konashevyc, 2017).

While some papers focus on specific cases where blockchain has been already implemented in the public domain, most of them continue to be hypothetical in nature about how blockchain can contribute and its potential in various services. Additionally, most of these paper focus on individual cases and do not offer a generalized overview of the outcomes. In order for policy makers to have a better overview of what to expect from blockchain in the light of their needs, it would be important to classify the blockchain applications and link them to different dimensions and implications by looking at various initiatives. This would also allow for the emergence of the societal challenges that this technology is inherited to face.

Blockchain Taxonomies

The versatility of blockchain technology, the application domains of blockchain and the different types of blockchain that could be associated with each application, have offered a good opportunity for various studies contributing to the classification of blockchain and the creation of a diversity of taxonomies. Each taxonomy is considered to be a separate category and would provide a way of structuring knowledge in a particular field (Glass and Vessey, 1995). Sarkitundu et al., (2016) are among the first to study the possibility of creating a taxonomy on the basis of blockchain platforms, as a first step into creating a wider taxonomy that would encompass the whole cryptocurrency ecosystem. Other early studies, such as Xu et al (2017) and Tasca and Tessone (2018), focus on a way of classifying, different blockchains on the basis of their architectural design. Wieninger et al. (2019) develop a blockchain taxonomy based on blockchain characteristics and how different types of blockchain interact. Weking et al. (2019) study the impact of blockchain technology on business models by either affecting existing ones or creating new ones altogether. Labazova et al. (2019) highlight the importance of developing a taxonomy of blockchain applications that categorize all blockchain

characteristics across different applications and create a taxonomy encompassing the main technical components of various blockchains. Recently, Alkhalifah et al. (2020) propose a taxonomy based on cybersecurity threats and the possible vulnerabilities, as a way of classifying certain aspects of blockchain.

Despite the increase of blockchain studies aiming at classifying it, it is worth mentioning that, so far, the resulting taxonomies mainly focus on the technical characteristics of blockchain and its various architectural settings. Also, the purpose of any taxonomy is based on its intended use, thus with a concrete idea of the users to be addressed. From the extensively technical nature of the aforementioned studies, it could be inherited that the focus so far has been on technology experts and developers. There is a shortcoming in current literature regarding blockchain with regard to implications, which makes it important classifying blockchain applications adopting this new lens, addressing decision-makers.

The users we mainly expect consist of policy makers, head of institutions of various nature in the public domain and even managers who are primarily concerned with the expected benefits that can be gained from a successful implementation. Our taxonomy's user pool also includes researchers and scholars wishing to underpin the advantages and limits of blockchain as assessed from real cases: this could be the starting point of further research in managerial and governmental studies regarding blockchain. Thus, the objective of our study is to classify the effects of blockchain applications in public domain: consequently, the meta-characteristics in our study relate to consequences and implications, with minimal interference to the characteristics of applied blockchain.

Methodology

Taxonomy Development Method

From a technical and performing perspective, blockchain has been considered from the very beginning as an evolutionary step towards a new way of thinking about information systems (Brando, 2016; Beck et al., 2017). Research continues to draw comparisons between blockchain and traditional information systems (Rossi et al., 2019), and goes as far as to consider blockchain as a new infrastructure and platform in information systems research (Costantinides et al., 2018). Under this perspective, we adopt the Nickerson et al. (2013) taxonomy development method especially designed for studies concerning Information Systems. This method proposes a process starting with presenting as a first step the meta-

characteristics, followed by the determination of ending conditions and the approach as summarized in Figure 1.

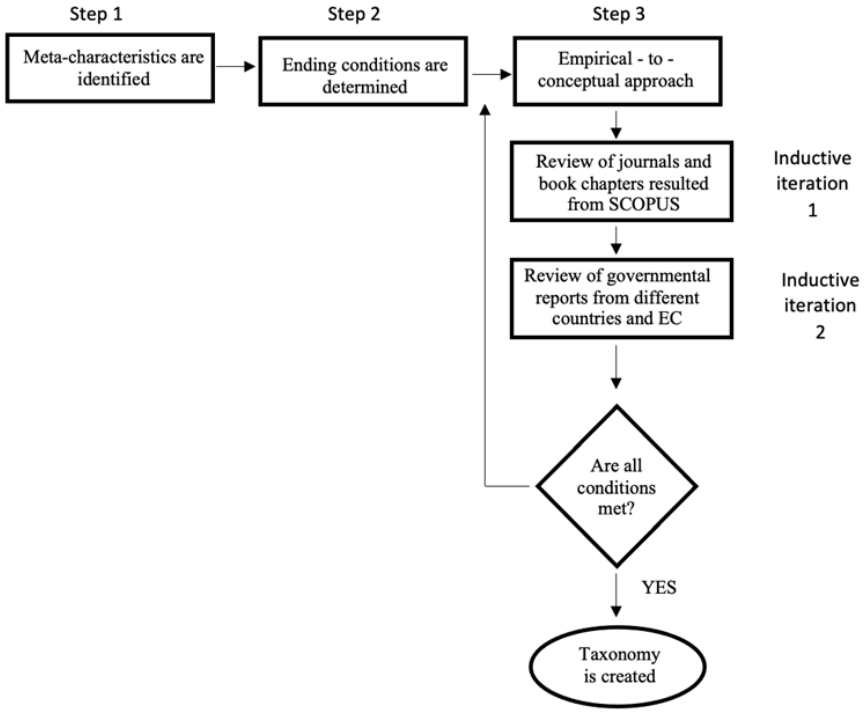

Figure 1. *Taxonomy Development Method*

We opted for an empirical-to-conceptual approach given that the main objective of the research is to look at observations and evidence coming from real-life case studies. The taxonomy was developed through two inductive iterations. For the first iteration, we compiled the list of dimensions, characteristics and applications that resulted from the list of publications we reviewed from SCOPUS. In the second iteration we did the same thing, this time analyzing the national and international governmental reports, which were identified through the first literature review. Since no dimension was added following this new iteration, the method was not repeated.

Eventually, the taxonomy is concluded, since also the ending conditions enlisted by Nickerson et al., (2013) are fulfilled. Each dimension highlights the main features of interest in the taxonomy: they are mutually exclusive and there were no dimensions added or merged/split in the last iteration. There is no cell duplication and at least one object is classified under each characteristic. Additionally, all the application cases in our domain of interest can be classified in the taxonomy making it comprehensive, and if a new application case would arise, the taxonomy is extensible enough for a new dimension to be added.

Search Strategy

For the purpose of this study, taking into consideration that the application of blockchain in the public domain could be very multidimensional, we focused on SCOPUS as our main database of research because of its multi-disciplinarity. To fully grasp the application of blockchain in our domain of interest, we made sure to include all words which would interrelate with "public domain" and "blockchain". The final search record included the words "public policy" or "public sector" or "government" or "public governance" and "blockchain" or "bitcoin" or "Ethereum" or "cryptocurrency" or "distributed ledger" or "smart contract".
At first, we included peer-reviewed journal articles, conference papers and the book chapters which resulted to match our criteria on SCOPUS. Eventually, considering the scope of our study, we found it useful to also add country reports and reports from the European Commission, which detailed any implications and outcomes resulting from the application of blockchain in any member country.

Selection Criteria

The search on SCOPUS resulted in 1,175 document documents to be reviewed. During the first screening process, the abstract of each document was investigated to match our selection criteria:

- Only case studies, reports on blockchain applications or literature reviews concerning the former which have already been implemented as a pilot phase or as full scope implementation have been considered
- Implementation had to be promoted by a government institution, whether local or national, and/or by a public administration body and/or related to government policy
- Not including any hypothetical or potential case studies, to make sure that the reflections of the output would be more reliable
- Written in English language
- No restriction applied about the field of study: included publications come from social sciences and engineering.

Subsequently, after the first screening based on the aforementioned criteria, and after the removal of any duplicate, a second screening consisted of reading the full document. This resulted in a total of 79 records from SCOPUS. Based on a snowball effect, some of the important government reports or press releases, which did not result from our initial database, were considered, and eventually 13 reports were added.

Data Organization and Coding

For the purpose of our study, we used NVivo 13 as a data management tool considering the number of articles under review. Considering the exploratory nature of our research, we applied open and axial coding to associate descriptive labels to the emerging themes and identify the connection between these themes.

Blockchain Initiatives

Considering the objective of this research and the focus on policy makers, it was important to also showcase some of the most distinctive blockchain initiatives in the public domain observed during the investigation. Figure 2. presents a summary of 22 of such initiatives that vary in nature and scope. In the later section we match these initiatives which consist of pilot projects or full-scale implementations with each of the dimensions emerging from the taxonomy.

	Blockchain Initiatives	Descriptions
B1	**UN Joint Staff Pension Fund**	Update of manual procedures and creation of an automated solution through a blockchain unchangeable process for delivering the annual Pension Fund Certificate of Entitlement to retired beneficiaries (Lacheca, 2021)
B2	**Chancheng - China**	Considered as the first blockchain initiative in e-government in China for managing digital identities and for using them as a one stop service by various government institutions (Hou, 2017; Al-Megren et al., 2018)
B3	**X-Road - Estonia**	Regarded as the backbone of e-Estonia, it allows for different public and private e-service information systems to collaborate and share information (Adeodato and Pournouri, 2020; Rana et al., 2021)
B4	**The British National Archives Archangel Project – UK**	Identified as an initiative to safeguard archives by fingerprinting documents at their receipt, it ensures the proof of provenance and integrity of each file (Bui et al., 2020; Bhatia and De Hernandez, 2019)
B5	**Exonum land title registry - Georgia**	Release of digital certificates attesting land titles and checking of property claims legitimacy (Goderdzishvili et al., 2018; Sobolewski and Allesie, 2021)
B6	**Blockcerts academic records - Malta**	Verifying academic credentials, academic records, and certificates (Sobolewski and Allesie, 2021)
B7	**Chromaway property transactions - Sweden**	Implementation of blockchain infrastructure for real estate transactions, mortgage contracts and related activities (Thakur et al., 2019; Sobolewski and Allesie, 2021)
B8	**uPort decentralized identity - Switzerland**	Providing a new automated data management and confirmation for e-government services (Sobolewski and Allesie, 2021)

B9	**Infrachain governance framework - Luxemburg**	Bringing together blockchain and regulatory and legal requirements through a governance model supplementing current technologies (Sobolewski and Allesie, 2021)
B10	**Pension Infrastructure – the Netherlands**	Implementing blockchain to the Pension Infrastructure for lowering costs and providing more transparent services to citizens (Sobolewski and Allesie, 2021)
B11	**Stjaderpas smart vouchers – the Netherlands**	Transfer into a blockchain infrastructure of the voucher system providing various discount services for low-income systems Stjaderpas (Sobolewski and Allesie, 2021)
B12	**Delaware Public archives - USA**	Pilot project aiming at making public records more accessible, also incorporating the retention and destruction of documents in compliance with law (Warketing and Orgeron, 2019)
B13	**Electronic voting - South Korea**	Casting votes, both online and offline on various issues such as regarding various community projects that would eventually get funded, etc. (Ojo and Adebayo, 2017; Jagrat and Channegowda, 2020)
B14	**Factom Land registry - Honduras**	Land registry to better protect local farmers' livelihoods and invest in diversifying their agricultural production (Alketbi et al., 2020)
B15	**Vehicle wallet partnership - Denmark**	Incorporating blockchain as the infrastructure of a digital asset management of vehicle's life cycle process (Chellasamy, 2019)
B16	**Syddjurs municipality - Denmark**	Prototype attaching smart contracts to the governmental processes to test the efficiency of blockchain in day-to-day processes (Krogsboll et al., 2020)
B17	**Bengal birth certificate - India**	Automated system of records based on blockchain when issuing birth certificates (Bhatia and De Hernandez, 2019)
B18	**Smart City Dubai - UAE**	Leveraging blockchain technology in various applications for transforming the United Arab Emirates into a blockchain haven (Al-Barguthi et al., 2019; World Economic Forum, 2020).
B19	**Asylum Procedure - Germany**	Pilot use of blockchain to coordinate processes across different authorities in the asylum procedure of migrants and refugees (Rieger et al., 2021)
B20	**Illinois Blockchain Initiative**	Series of use-case pilot programs aimed at exploring the potential of blockchain (Sullivan, 2021)
B21	**Project Jasper – Bank of Canada**	Four-phase project to explore blockchain and digital ledger technology in the central bank environment for determining technologies' capabilities and feasibility (Reddick, 2021)
B22	**Food Standards Agency - UK**	Pilot project implemented by the Food Standards Agency for tracking meat to provide higher transparency in the food sector

Figure 2. *Blockchain Initiatives*

Taxonomy of Blockchain Outcomes

The final taxonomy of blockchain outcomes comprises of 5 dimensions: Use cases, Organizational Extensions, Type of Users, Benefits, Risks and Challenges, Public Value. Two dimensions comprise subdimensions that we have compiled to better label all the items identified from the coding. Figure 3 gives an overview of the identified dimensions and subsets.

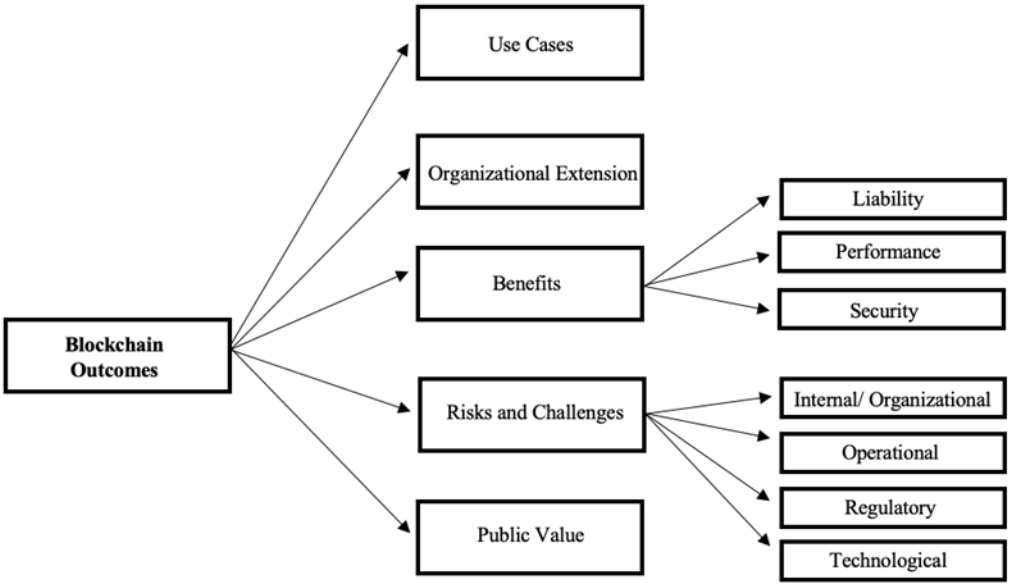

Figure 3. *Blockchain Taxonomy*

The next section will detail each dimension, providing an explanatory description of each category identified under each dimension. Additionally, each category is matched with a third column listing the examples of blockchain initiatives summarized above which identified from our literature review and coding, presented the characteristics of that same category.

Use Cases

We refer to use cases to describe the various blockchain application domains that have been identified across all industries. Through use cases, we aim at specifying the main purposes that blockchain has been explored for. Table 1 presents the identified seven use cases that encompass the reviewed applications in the public domain.

Use Cases	Description	Initiatives
Digital records	Application for records sharing and storing, registry services, securing information integrity	B2, B3, B4, B5, B7, B10, B12, B14, B18, B19, B20, B22
Supply chain	Tamper-proof and time stamped end-to-end tracing of the supply network distributing any product from the supplier to the final receiver that also replaces manual processes	B15, B22
Identity management	Application for providing a decentralized proof of identity by implementing smart contracts to manage data disclosure through explicit user consent	B1, B6, B8
Bills and Payments	Automating transactions involving payments that meet the regulations, through the smart contract protocol	B3, B10, B16, B18, B21
Welfare distribution	Application to various transformative ways of supporting social welfare, such as through secure e-vouchers, distribution of funds or monitoring of welfare expenditures	B11
E-voting	Application to any process involving the casting or counting of votes done electronically	B13
Legal enforcement	Applications that aid the fight against financial crimes, tracing criminality, securing the change of custody for evidence, etc.	B12, B19

Table 1. *Use Cases*

Organizational Extension

The concept of organizational extension denominates the extent that the blockchain has been applied to. More specifically, it relates to whether blockchain has been applied to only a local application that can be a municipality, single administration unit, small local voting, or to a wider application. The latter can be for instance a nationwide blockchain initiative for various institutions or even transnational in the case where the same blockchain is the backbone of an initiative undertaken by different countries that cooperate with each other, such as in the case for instance of the European Union. Table 2 shows a summary of the three types of organizational extension and a brief description of each of them.

Organizational Extension	Description	Initiatives
Local	Applications by a single organizational unit or institution and intended for local use	B2, B8, B11, B12, B13 B16, B17, B18, B20

National	Applications for nationwide services	B3, B5, B6, B7, B9, B10, B14, B15, B19, B21, B14, B22
Transnational	Applications extended to different nations	B1, B3, B4

Table 2. *Organizational Extension*

Benefits

For the purpose of our taxonomy development, we consider benefits as the advantages perceived or the measured profit gained after the successful application of blockchain. In this regard, we were able to identify altogether 13 benefits, which we grouped into three main categories for interpretation purposes. The first set of benefits regards the fact that blockchain features offer new ways for achieving transparency, accountability, and authenticity at every transaction. The second set of benefits concern the advantages that regard the performance aspect of processes, while the last set highlights the successful implications of blockchain in terms of elevated security and risk management. Table 3 describes in detail each of the benefits identified and the distinction between them.

Benefits		Description	Initiatives
Liability	Transparency	Possibility of viewing at any time any transaction occurring on the chain	B2, B3, B5, B9, B10, B13, B15, B19, B21, B16
	Accountability	Availability of audit trail that can showcase by whom and when any transaction was made	B1, B11, B18, B19, B20
	Authenticity	Quality of data that remains unaltered and legitimate	B2, B5, B9, B14, B15
Performance	Efficiency gains	Efficiency gains due to the automation of the operations	B1, B2, B3, B5, B6, B7, B8, B10, B11, B12, B15, B18, B19, B21
	Cost reduction	Reduced cost and cost saving resulting from removal of intermediaries, faster operations, lower capital requirements	B1, B5, B6, B7, B8, B10, B11, B12, B15, B16, B21, B22
	Time reduction	Reduction of time in performing different various processes	B1, B7, B18, B22
	Fault tolerance	Ability of a system to continue to reach consensus despite malicious activity	B5
	Reduction of human and procedural errors	Removal of interfaces where human errors could have an impact upon	B12, B16, B21, B22

	Streamline of Procedures	Reduction of long bureaucratic procedures and operations	B3, B16, B18
	Interoperability	Capability to share and exchange information easily through various blockchain systems	B2, B3, B19
Security	Immutability	Capability of information and transactions stored in blockchain to remain unalterable and private if needed	B1, B2, B4, B7, B12, B13, B14, B18, B19, B20, B21
	Compliance	Capability to operate under complex and stringent regulatory environments	B3, B10, B16, B19
	Resiliency	Capability to operate as a decentralized network without a single point of failure	B7, B8, B9, B10, B15, B20

Table 3. *Benefits*

Risks and Challenges

We identify the risks and challenges as the issues and constraints observed in association with the application of blockchain in various pilots or full functioning projects. We show a classification of the 16 different challenges identified into four main categories. Internal organizational constraints regard the issues related to the people or policies of the organization where blockchain has been applied to. Operational constraints regard the limitations observed from an operational perspective, while regulatory constraints related to laws and regulations, or a/the lack thereof of proper legislation concerning blockchain. Lastly, technological constraints regard the restrictions related to the technology itself, either due to its architecture or other individual features that are perceived as problematic. The risks and challenges are indicated in Table 4.

Risks and Challenges		**Description**	**Initiatives**
Internal Organizational Constraints	High transaction / running cost	Any fees regarding the development, maintenance and running of blockchain	B2, B3, B10, B12, B16
	Distrusting organizational culture	Lack of trust in adopting blockchain and/or changing the way of doing things	B1, B6
	Lack of proper understanding	Lack of proper information on how blockchain functions or negative public perception regarding blockchain	B1, B3, B18
Operational Constraints	Lack of expertise	Limited knowledge and experience with blockchain and need of new resources	B3, B10, B18, B14

	Infrastructure immaturity	Lack of infrastructure to maintain the network and nodes and avoiding interruptions at any time	B9, B14, B22
	Scalability	Lack of capability to process very large amount of transaction data in a short amount of time	B4, B7, B8, B10, B19, B20
Regulatory Constraints	Regulatory uncertainty	Lack of regulations, especially related to information sharing and reporting	B8, B16, B22
	Law volatility	Uncertainty of how to manage smart contracts in the light of changes in law, considering their immutability feature	B16
	Lack of frameworks	Absence of frameworks regulating governance, control, and risk management	B2
Technological Constraints	Premature technology	Lack of stable, proper development of blockchain	B20, B21
	Data confidentiality	Concerns over privacy, the long-term preservation of data, concurrence with existing rules	B2, B5, B20, B21, B14, B22
	Security concerns	Various security risks and vulnerabilities associated with a still new technology	B2, B16, B20, B14
	Immutability	Difficulties in changing the records if a mistake has been made or if a law changed	B11, B16
	Reliability	Unreliability of records due to various threats, such as third parties or minimal control over nodes	B14
	No added value	Stance on traditional IT systems suffice to integrate processes without the need of introducing blockchain	B16, B21
	High energy consumption	Huge power consumption by blockchain	B5, B20

Table 4. *Risks and Challenges*

Public Value

The last dimension identified in our taxonomy regards public value, defined as the value that a successful blockchain application may contribute to the society. It could be considered as a benefit with a wider scope. Differently from Cledou et al. (2018) who simply link public value to different benefits perceived by users through smart mobility services but do not consider it a taxonomy dimension of its own, we consider public value as a separate dimension according to the high presence in the application cases and literature reviewed. Table 5 depicts the five different public values identified by this study.

Public Value	Description	Initiatives
Trust	Establishment or increase of public trust in the public organizations or public services and policies	B2, B3, B4, B5, B6, B7, B9, B15, B16, B17, B22
Democracy	Enforcement of democratic values including, but not limited to, equality, social justice, diversity	B13
Legitimacy	Conformity to law or accordance with rules and regulations	B19
Multilateralism	Stimulation of public administrations to foster collaboration between countries	B3
Efficiency	Increased efficiency of public services	B1, B2, B8, B10, B11, B12, B18, B20, B21
Anti-Fraud	Prevention of fraudulent behavior and corruption	B5, B6, B13, B14, B18

Table 5. *Public Value*

Findings per Case Study

Based on the results emerging from the taxonomy, a comprehensive summary of the categories per dimension that each case study is associated with is depicted in Table 6. As is portrayed from the table, each blockchain initiative alongside its distinctive characteristics, has been noted to offer a series of distinctive benefits, while also facing various challenges during implementation.

Blockchain Initiative	Use Cases	Org. Extension	Benefits	Risks & Challenges	Public Value
UN Joint Staff Pension Fund	Identity management	Transnational	• Accountability • Cost reduction • Efficiency gains • Time reduction • Immutability	• Distrusting organizational culture • Lack of proper understanding	Efficiency
Chancheng - China	Digital records	Local	• Transparency • Authenticity • Efficiency gains • Interoperability Immutability	• High transaction / running cost • Lack of frameworks • Data confidentiality • Security	Trust, Efficiency

				concerns	
X-Road - Estonia	Digital records, Bills and payments	National Transnational	• Transparency • Efficiency gains • Streamline of Procedures • Interoperability • Compliance	• Lack of expertise • High transaction / running cost • Lack of proper understanding	Trust, Multilateralism
The British National Archives Archangel Project - UK	Digital records	Transnational	• Immutability	Scalability	Trust
Exonum land title registry - Georgia	Digital records	National	• Transparency • Authenticity • Efficiency gains • Cost reduction • Fault tolerance	• High energy consumption • Data confidentiality	Trust, Anti-Fraud
Blockcerts academic records – Malta	Identity management	National	• Efficiency gains • Cost reduction	• Distrusting organizational culture	Trust, Anti-Fraud
Chromaway property transactions - Sweden	Digital records	National	• Efficiency gains • Cost reduction • Time reduction • Immutability Resiliency	• Scalability	Trust
uPort decentralized identity - Switzerland	Identity management	Local	• Efficiency gains • Cost reduction Resiliency	• Regulatory uncertainty • Scalability	Efficiency
Infrachain governance framework - Luxemburg	N/A	National	• Transparency • Authenticity • Resiliency	• Infrastructure immaturity	Trust
Pension Infrastructure – the Netherlands	Digital records, Bills and payments	National	• Transparency • Efficiency gains • Cost reduction • Compliance • Resiliency	• Scalability • High transaction / running cost • Lack of expertise	Efficiency
Stjaderpas smart vouchers – the Netherlands	Welfare distribution	Local	• Accountability • Efficiency gains Cost reduction	• Immutability	Efficiency

Delaware Public archives - USA	Digital records, Legal enforcement	Local	• Efficiency gains • Cost reduction • Reduction of human and procedural errors • Immutability	• High transaction/ running cost	Efficiency
Electronic voting - South Korea	E-voting	Local	• Transparency • Immutability Authenticity	• Regulatory uncertainty	Democracy, Anti-Fraud
Factom Land registry - Honduras	Digital records	National	• Immutability	• Lack of expertise • Infrastructure immaturity • Data confidentiality • Security concerns • Reliability	Anti-Fraud
Vehicle wallet partnership - Denmark	Supply chain	National	• Efficiency gains • Resiliency • Authenticity • Transparency • Cost reduction	N/A	Trust
Syddjurs municipality - Denmark	Bills and payments	Local	• Cost reduction • Reduction of human and procedural errors • Streamline of Procedures • Compliance	• High transaction / running cost • Regulatory uncertainty • Law volatility • Security concerns • Immutability • No added value	Trust
Bengal birth certificate - India	Digital records	Local	• Immutability • Authenticity	• Lack of expertise • High transaction/running cost	Trust
Smart City Dubai - UAE	Digital records, Bills and payments	Local	• Accountability • Efficiency gains • Time reduction • Streamline of Procedures • Immutability	• Lack of proper understanding • Lack of expertise	Anti-Fraud, Efficiency
Asylum Procedure - Germany	Digital records, Legal enforcement	National	• Transparency • Accountability • Efficiency gains • Interoperability • Immutability • Compliance	• Scalability	Legitimacy

Illinois Blockchain Initiative	Digital records	Local	• Transparency • Accountability • Immutability • Resiliency	• Scalability • Premature technology • Data confidentiality • Security concerns • High energy consumption	Efficiency
Project Jasper – Bank of Canada	Bills and payments	National	• Efficiency gains • Cost reduction • Reduction of human and procedural errors • Immutability	• Premature technology • Data confidentiality • No added value	Efficiency
Food Standards Agency - UK	Supply chain	National	• Time reduction • Cost reduction • Reduction of human and procedural errors	• Data confidentiality • Regulatory uncertainty • Infrastructure immaturity	Trust

Table 6. *Case Studies*

Discussion and Implications

The diffusion of an emergent technology, especially until there is a high uncertainty around it, is always associated with comparing incremental benefits that would come with a successful adoption and the cost attached to such a move (Hall and Khan, 2003). Similarly, two main dimensions emerging in our taxonomy are benefits and risks. Comprehending the various gains witnessed in different initiatives around the world would aid in an easier acceptance of the technology. As regards benefits, it should be specified though that the benefits, despite being generalized and coming from different sources, should not be taken at face value. De Giovanni (2019) in his study regarding the application of blockchain in eco-digital supply chains makes a point in stating that advantages of implementing blockchain, despite being theoretically evident, should be accompanied by detailed analysis in terms of the involved costs or the real convenience.

Similarly, the second important emerging dimension are the constraints and challenges coming along with this technology. Risk identification is considered the first step in managing risks and minimizing any hiccups that may arise (Tchankova, 2002). This makes it possible for

some risk to be mitigated and addressed already at a pre-implementation phase. In addition, considering that some risks recognized in literature are associated with technical aspects of blockchain, their identification should also motivate developers at looking into blockchain to recognize possible improvements. This would elevate the status of blockchain and help further applications of blockchain, not only in the public domain.

Public value is another important dimension considering the domain under consideration. For Moore (1995), public value is one of the main components of his famous triangle depicting the main elements for a strategic management in the public sector. Similarly, Meynhardt et al., (2017) states that the value of public administrations is closely connected to the public value they provide through their services. It should be also underlined that any system change aimed at public service transformation should put public value at the top of the change process in the public domain (Tonurist et al., 2019). Therefore, by evidencing the various public values that blockchain is able to contribute to could be expected to help in delineating the importance of this technology in the public domain.

This taxonomy aims to establish a better understanding of blockchain applications and facilitate the sharing of knowledge about blockchain initiatives and their outcomes. We expect its main findings and classifications to support both decision-makers and academic researchers wishing to explore the topic. The implications are both for practice and research and can be summarized as following.

For policy makers in the public domain interested in implementing blockchain in their practices and institutions, this taxonomy is a starting point for understanding the variety of scopes a blockchain adoption relate to, also through several use cases presented. Also, it aids policy makers to consider the benefits and risks associated with its application, and the possible.

We believe this taxonomy to have important implications for academic research. Considering that the taxonomies created around blockchain have predominantly focused on the technical characteristics, an outcome-based taxonomy defines a new mapping and standardization of information regarding blockchain. In addition, this study bridges the need for investigation of blockchain in public domain and the limited research encompassing different areas of the public domain.

Challenges, Limitations and Future Research Directions

The main challenge observed during this study refers to the scarcity of detailed data on

the results of the blockchain applications in the various sectors provided in most studies. Very often, the blockchain application is associated with what can be considered as expected benefits and implications, yet not supplemented with empirical findings certifying the claims. Another challenge regards the lack of a repository regarding blockchain initiatives per country. Some countries have indeed written reports on some of their initiatives, but such reports are still impaired due to different reasons. The first reason being that they are not yearly reports, thus do not offer a follow-up on important initiatives. Additionally, such reports mostly aim at studying successful cases: despite their importance, they do not cover pilot projects or prototypes that, albeit having failed, would offer an insightful view on the reasons behind such failures.

In terms of possible limitations, this study focuses on applications undertaken in the public domain. Being the blockchain adopted in many fields, it is important to consider that results could differentiate based on the domain of study. Furthermore, new blockchain applications are being deployed every day, which may raise the need to extend the taxonomy or compress it in case some of the issues have been addressed. Still referring to the need of progressing research on blockchain, this study creates the opportunity for further investigations looking more specifically to possible connections between our taxonomy and technical values researched by previous studies. This would shed light on possible links between blockchain outcomes and some technical characteristic, such as type of blockchain, consensus mechanisms, encryption.

Additionally, it would be interesting a similar study adapted to the private sector, to see whether there exist differentiations based on the nature of the industry blockchain is applied to. Also, considering that most research on blockchain today aims at improving the limitations of the technology from an architecture and security point, future studies could shift the attention on challenges going beyond the technical perspective.

Conclusion

Since its introduction, blockchain has become an ever-growing topic of interest and has seen a surge in applications in various domains. There has been an increase in governmental initiatives around the world to explore further this technology, with many institutions and organizations in the public domain already having started to implement blockchain for various scopes and purposes.

In this paper we propose a taxonomy able of classifying the outcomes of the

aforementioned initiatives in the public domain. Different from previous taxonomies, our study shifts the focus from the technical characteristics of blockchain to the implications regarding its adoption. Along the process, we recognized six different dimensions, each with its own characteristics and features. In addition, through extensive literature research, this study provides a list of some important initiatives in public domain and matches these initiatives with the dimensions recognized in the taxonomy.

This study contributes to the current state of research on blockchain by providing a new way of classifying blockchain applications and, more specifically, by focusing on the public domain where such studies lack. The proposed taxonomy offers valuable insight to policy makers considering adopting blockchain, by offering an overview of the lessons learned from previous applications. It also enables decision makers to understand the possible challenges, offering the opportunity of tackling potential constraints in an initial phase.

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Key Terms and Definitions [3]

Blockchain: A decentralized digital ledger that records executed transactions in the form of blocks with a cryptographic hash and specific timestamp.

Distributed Ledger: A type of a database that records digital transactions whose information and details are documented in multiple places simultaneously.

Smart Contract: A self-executing contract whose terms and agreements are written in the form of computer code that ensure the execution of transactions.

Digital Transformation: A transformation referring to the change in business processes and culture due the introduction of digital technology.

Public Domain: The services owned and controlled by the government and/or despite being private are funded by governmental authorities.

Taxonomy: A system of classification according to predefined specific criteria.

Public Value: The benefits and rights contributing to the society.

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CHAPTER 2

Tensions Affecting Blockchain-based Information Infrastructures in Public Administration [4]

Abstract

The emergence of blockchain has marked the dawn of a new era in decentralized technologies. Recent years have provided significant developments in extending the adoption of the unique capabilities of blockchain for a variety of use cases. As such, blockchain has attracted much attention from academics, businesses and governments alike, which have recognized the inherent attributes of the technology in providing a new spectrum of opportunities for revolutionizing services and innovation. Despite the potential of blockchain and its distinctive features, particular domains such as Public Administration (PA) appear to be among the most hesitant when it comes to introducing blockchain. Research in this context has also been limited, particularly with regard to the challenges and reasons for opposing a possible adoption. In this paper, we argue that a way of looking at blockchain adoption in PA, is through the lens of Information Infrastructures (IIs), due to a series of converging elements between IIs and blockchain. Hence, the aim of our research is to understand how blockchain can be successfully integrated into current PA infrastructures by identifying the tensions hindering its adoption. The main findings are constructed on the basis of evidences gathered through interviews with public decision-makers in Italy, in an attempt to better understand their perceptions and experiences with blockchain. A total of nine tensions have been identified, and the findings aim at contributing to a new understanding of blockchain associated challenges as a way of facilitating larger scale adoptions in the future.

Keywords: blockchain, information infrastructure, public administration, tensions

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This study has been submitted to a peer-reviewed journal and is awaiting evaluation.

Introduction

Blockchain has been promoted as an evolutionary technology able of radically transforming how data is stored and distributed through an innovative technique of recording transactions. This technology has provided a new outlook on how trust is fostered, due to its main characteristics that make every record transparent, unalterable, secure, and easily auditable (Iansiti & Lakhani, 2017; Casey et al., 2018; Hughes et al., 2019). Whilst the first wave of studies concerning blockchain was mainly focused on cryptocurrencies, current research has focused on the potential of blockchain in various other domains where the management of trusted information is critical (Zhao et al., 2016; Abou Jaoude & Saade, 2019; Spahiu et al., 2022). As such, different governments and governing agencies have already started to adopt blockchain technology to improve a distinct range of activities and services. In particular, Public Administration (PA) has been noted to potentially benefit from the blockchain technology given how data certification, traceability and transparency are prerequisite of all activities pertaining to PA (Scholl & Bolivar, 2019; Moura et al., 2020; Rot et al., 2020). In this domain, blockchain has been considered an advantageous technology able of elevating public service efficiency, minimizing bureaucratic procedures and fostering trust (Navadkar et al., 2018; Batubara et al., 2018; Cagigas et al., 2021).

Subsequently, given the various benefits associated to blockchain, different studies have paralleled the distinct features pertaining to this technology to the properties and characteristics of Information Infrastructures (II) (Ølnes, 2016; Jabbar & Bjorn, 2017; Constantinides et al., 2018). Furthermore, research has also explored the concept of blockchain-based IIs in the public domain, highlighting the opportunity presented by the technology to create new decentralized infrastructures for governments and public services (Ojo & Adebayo, 2017; Ølnes & Jansen, 2018).

Nevertheless, despite the potential of blockchain in PA and its ability to embed different features of IIs, most initiatives continue to be very marginalized and the adoption in the PA domain is low. Research points out that apart from its potential advantages, blockchain adoption in PA appears to be accompanied by an array of challenges (Batubara et al., 2018; Spahiu et al., 2022). However, such studies focus only on the blockchain characteristics and fail to look at how the emerging issues related to blockchain are affected by the inherent nature of the domain in which is being adopted. In addition, different studies have identified the need to further theorize on the main challenges related to the blockchain as the most plausible way of facilitating future adoptions (Zheng et al., 2018; Monrat et al., 2019). Moreover, studies

linking blockchain and IIs merely focus on distinguishing the common features or underlying the prospect of the blockchain technology as an infrastructure (Ojo & Adebayo, 2017; Ølnes & Jansen, 2018. Nevertheless, such studies do not account for the reasons why despite such potential, the diffusion of blockchain in different areas such as PA remains limited.

Therefore, this paper aims at answering the call on the aforementioned limitations by addressing the following research question: *"How can blockchain be integrated into PA infrastructures?"* In order to address this research question, we look at blockchain as an II and seek to find the challenges impeding blockchain-based IIs in the PA. In this regard, we focus on tensions to orient our theoretical analysis of challenges as they provide a viable way for understanding in depth the issues behind the development of infrastructures (Edwards et al., 2007). Lastly, we adopt the Ribes and Finholt (2009) framework to classify the main tensions emerging from the analysis in an attempt to better organize the diversity in our findings.

Our research is mainly based on semi-structured interviews conducted to top-level public decision-makers, in the context of the Italian PAs. Italy provides a significant setting for investigating blockchain due to a series of initiatives taken by Italian PAs surrounding blockchain, both from local and central government, in promoting and encouraging potential use cases regarding the technology itself (European Commission, 2018; Senato della Repubblica, 2019; Bianchini & Kwon, 2020). In addition, by focusing on a single country, we expect the level of abstraction to be lower, whilst the results would be able to relate to a broader spectrum of applications, due to the rich context presented by the country under investigation.

This study aims at providing empirically based contributions on the organizational implications of blockchain use in the PA. It contributes to the theoretical development concerning the evolution of IIs based on blockchain, whilst also providing from a practical point of view, an important set of tensions to be addressed in the development of blockchain-based IIs in PAs. The paper is also directed towards developers of blockchain technology and public infrastructure administrators, who could benefit from this research by anticipating the limitations and addressing the issues, as evidenced by the analysis of this study, in an attempt to provide fewer rejecting circumstances to the blockchain adoption.

Related Works

An Overview of Blockchain

Blockchain consists of an inherently distributed digital ledger able of recording

information pertaining to any transaction in an immutable manner across a specific blockchain based network (Nofer et al., 2017; Hawlitschek et al., 2018). Once the integrity of the data is validated through cryptographic means, it is registered on the network in the form of "blocks", which describe permanent records stored indefinitely (Di Pierro, 2017; Hawlitschek et al., 2018). In addition, a self-executed protocol integrated in the form of smart contracts within the blockchain ensures that predetermined conditions are met and self-enforced (Mendling et al., 2018; Mohanta et al., 2018; Wang et al., 2019). Thus, the innovation accompanying blockchain and smart contracts has presented new ways of governance and has challenged traditional ways of managing transactions, determining relational contracting and establishing trust (Lacity, 2018; Davidson et al., 2018; Abou Jaoude & Saade, 2019).

As a result of its unique technical features, blockchain has been regarded as one of the most disruptive technologies in recent years (Frizzo-Barker et al., 2020; Pan et al., 2020) able of delivering a series of benefits, especially in terms of security, reliability and immutability of records (Iansiti & Lakhani, 2017; Casey et al., 2018; Vella & Gastaldi, 2021; Spahiu et al., 2022), in addition to superior traceability and auditability (Hughes et al., 2019; Pereira, 2019; Ali et al., 2021). Hence, blockchain has been attributed to elevate transparency and minimize fraud, as all transactions upon validation remain unable to be altered (Swan, 2015; Frizzo-Barker et al., 2020; Rot et al., 2020; Saheb & Mamaghani, 2021). Subsequently, in turn this has shown to be a principal factor leading to enhanced coordination and trust between organizations and actors being serviced by a blockchain network (Malhotra et al., 2022; Spahiu et al., 2022). In addition, research has shown that blockchain adoption can lead to a series of efficiency gains such as in terms of cutting down expenses and cost effectiveness (Catalini & Gans, 2020; Spahiu et al, 2022), reduction of manual tasks, processing time and possible human error (Hughest et al., 2019).

There exist three main blockchain networks that differ based on the consensus mechanism and degree of openness: public, private and consortium (Guegan 2017; Zhang & Lee, 2020; Dib et al., 2018). Each of these networks has its own regulations and restrictions with regard to admission and level of accessibility. The choice of blockchain mostly depends on the needs, value trade-offs, strength and weaknesses of each system. Public blockchains, are completely open and can have unlimited number of anonymous nods joining the network making them exceptionally anonymous. Public blockchains are considered to be highly secure and transparent with every transaction fully verifiable but suffer from scalability issues and extensive power consumption given the potential network size (Lai & Chuen, 2018; Yang et al., 2020). Private blockchains on the other hand, allow only verified members to join, and are

considered more efficient in terms of transaction processing rate (Pongnumkul et al., 2017; Lai & Chuen, 2018). Lastly, consortium blockchains consist of hybrid versions of the public and private blockchain usually opted by systems of organizations that wish to collaborate on a decentralized yet closed networks (Dib et al., 2018).

Subsequently, the different types of blockchain and the positive prospects associated with the technology overall, have put blockchain on the focus of business and research communities alike. Nevertheless, despite the potential of blockchain technology, full adoption and deployment continue to be challenging and low adoption rates in different domains remain a systematic concern that needs to be addressed (Iansiti & Lakhani, 2017; Zheng et al., 2018; Monrat et al., 2019). In addition, most scholarly articles focus on the technical aspects of such ledger and there is an absence of studies relating the characteristics, benefits and challenges of blockchain adoption with regard to established theories (Monrat et al., 2019; Pelt, 2021). Therefore, the only way forward should include looking at different models and theories as an important lens in aiding our understanding of certain aspects of blockchain technology that affect adoption (Hughes et al., 2019). In addition, different studies also underline the need to study blockchain from the perspective socially embedded patterns (Ghosh, 2019; Rossi et al., 2019) and different level of analysis such as users, platforms and industries (Risius & Spohrer, 2017). Eventually this could be expected to expand debate on blockchain application to underline any issues stemming from aligning different organizational, cultural, and regulatory frameworks with the transformative nature of the technology itself.

Blockchain in Public Administration

Due to its distinctive characteristics, there is an emerging consensus about the potential of blockchain to positively transform the public domain into offering new ways of managing and delivering public services (Ølnes et al., 2017; Berryhill et al., 2018). Governments from around the world primarily started to experiment and test the blockchain technology for record keeping and notary purposes (Konashevych & Poblet, 2018), but as the need to adopt new technologies to improve service delivery becomes more imminent, blockchain soon started to be explored for an array of other applications such as in healthcare (Angraal et al., 2017; Höbl et al., 2018; McGhin et al., 2019; Farouk et al. 2020), education (Skiba, 2017; Bhaskar et al., 2021) and smart cities (Biswas & Muthukkumarasamy, 2016; Bhushan et al., 2020). Today, as the potential of blockchain technology remains in the spotlight of researchers and practitioners, the different government-initiated blockchain projects have been dedicated to delivering more efficient and more responsible public services to citizens (Batubara et al., 2018; Berryhill et

al., 2018; Cagigas et al., 2021).

There are three main objectives in the realm of public services for which blockchain is being predominantly considered advantageous: primarily as a promoter of more efficient public services delivered to citizens (Navadkar et al., 2018; Cagigas et al., 2021); secondarily to respond better to demand and reduce bureaucratic processes through digitalization of databases (Batubara et al., 2018; Salnikova et al., 2019); and lastly, for integrating processes of different governing bodies and fostering trust between institutions (Navadkar et al., 2018; Batubara et al., 2018; De Filippi et al., 2020). Such objectives are especially relevant for the PA, which continues to strive in making processes more efficient, transparent and interoperable (Shava & Hofisi, 2017). Due to such inference, research has shown that blockchain can have a positive impact to PAs, as it can offer new ways of addressing contemporary issues that relate to the structure and dynamics of PAs (Moura et al., 2020). More specifically in this regard, studies indicate that blockchain can be especially instrumental for data processing and security, where the technology has shown potential in providing immutable and tamper proof records (Ølnes et al., 2017). In addition, the attributes of blockchain technology have been related to the possibility of enhancing institutional procedures and offering new models of state regulation by modernizing processes and making them more transparent (Scholl & Bolivar, 2019; Moura et al., 2020).

Most of the studies linking blockchain and PA have focused on evaluating the technical aspects of blockchain with respect to the current needs being faced by PA and public policy makers (Salnikova et al., 2019; Moura et al., 2020; Rot et al., 2020 Treiblmaier & Sillaber, 2020). Other studies have been predominantly concerned on the blockchain adoption in PA drawing on the perspective of specific countries (Hou, 2017; Mahula, 2021; Ahmetbek & Špaček, 2021). Furthermore, studies such as Ølnes et al. (2017) provide classification of the benefits of blockchain adoption for specific purposes such as information sharing in the PA, whilst Spahiu et al. (2022) build on the results of blockchain adoption in different PAs to create a taxonomy of the main outcomes. In addition, literature review based studies have concluded that the application of blockchain in PA is an important avenue for governments as it is regarded to have a positive effect on amplifying public value through facilitation of democracy, reduction of corruption, more effective interoperability between governing bodies, and increase of trust in public organizations (Atzori, 2015; Moura et al., 2020; Spahiu et al., 2022). Lastly, considering all the set of benefits associated to blockchain and the nature of the technology, recent studies have also explored the concept of blockchain as an II specifically applied to the public sector and government (Ojo & Adebayo, 2017; Ølnes & Jansen, 2018). Such studies

highlight how blockchain embeds different dynamic attributes pertaining to open data IIs and the characteristics associated with the technology offer new robust solutions for next generation IIs in governments and public services alike (Ojo & Adebayo, 2017; Ølnes & Jansen, 2018).

Nevertheless, despite its numerous advantages including various attributes associated to IIs, what can be inferred from the current body of knowledge is the fact that the adoption of blockchain in PA remains limited. Whilst digital transformation has provided a new avenue for opportunities for PA, adoption of new technologies in this domain has proven challenging (Dunleavy et al., 2006; Shava & Hofisi, 2017), with public officials remaining averse to change (Buurman et al., 2012; Cagigas et al., 2022). More specifically with regard to blockchain, there is currently a grey area in literature related to how blockchain can be integrated more into current PA's IIs considering the low adoption rate in this field. A potential way of addressing such issue is by looking at challenges, nevertheless, the restricted number of studies looking at issues related to blockchain adoption in PA only refer to the distinct nature of PA as a hindering factor but make little inference on the technology itself as potential cause of concern (Hyvarinen et al., 2017; Novadkar et al., 2018; Cagigas et al., 2021). In addition, there is a call for more interdisciplinary studies that go beyond the technological paradigm of blockchain towards a more comprehensive understanding of its consequences and constraints in real contexts (Ølnes et al., 2017; Rossi et al., 2019). Therefore, the aim of this study is to address the aforementioned limitations present in literature regarding blockchain, by providing evidence-based results on how blockchain can be integrated into PAs infrastructures by looking at the challenges and issues that can play a role in restraining from large scale adoption.

Theoretical Framework

Blockchain-based Information Infrastructure

The term "Information Infrastructure" can be used to describe an open and shared socio-technical system that continues to evolve and comprises of a variety of actors, capabilities, processes and procedures (Hanseth & Lyytinen, 2016). Additionally, following Hanseth and Monteiro (1998) seminal work, Information Infrastructures consist of a set of distinct key aspects that identify their nature and main characteristics, namely: 1) IIs are designed to have an enabling function that could either improve existing structures or support new activities, 2) can be shared by a collection of users across multiple IT capabilities, and 3) can potentially be open to any number of stakeholders and applications. Based on such characteristics, IIs are considered as heterogeneous socio-technical networks that encompass more than just

technology and are developed by either improving or extending pre-existing installed bases (Hanseth & Monteiro,1998; Ølnes & Jansen, 2018). Also, given the dispersive nature of IIs, a distinctive feature of such structures is the fact that ownership and control are non-centralized but rather negotiated and distributed among the network (Weill & Broadbent, 1998; Ciborra & Hanseth, 1998). Consequently, such characteristics showcase the importance of striking a balance between the architectural and governmental elements in the shaping and evolution of IIs (Henfridsson & Bygstad, 2013, Tiwana, 2014; Constantinides & Barret, 2014).

All the aforementioned elements are congruent with both the intent for use and design of the blockchain technology. Blockchain is basically a distributed technology and, based on the type of blockchain, the level of openness in a blockchain network can allow for any relevant actor to become part and for the blockchain platform to be shared among different community of users (Ali et al., 2021; Yang et al.,2020). In addition, evidence coming from the successful blockchain implementations so far, have shown that blockchain has the potential to decrease the complexity and improve existing infrastructures in various domains including finance, health sector, and government (Ojo & Adebayo, 2017; Farouk et al., 2020). In a blockchain network the power dynamics can consist of a polycentric governing system which could replace traditional centralized authority by a trustless alternative that assigns specific powers to each node in the network (Zachariadis et al., 2019; De Filipppi et al., 2020). Such similarities between blockchain and IIs have also been evidenced through various studies. Ølnes (2016) was among the first to create a comparison between the properties of IIs and blockchain. Additional research has also showcased how the innovative features of blockchain technology could in turn be expected to create a new global II that can be trusted and not distorted though a non-centralized information sharing (Avital et al., 2016; Beck et al., 2017; Jabbar & Bjorn, 2017; Constantinides et al., 2018).

Lastly, additional studies such as Ribes and Finholt (2009) concur with Hanseth and Monteiro (1998) and affirm that the nature of an infrastructure is distinguishable from any other structure because it is persistent in time, can be reused and fosters inclusion and accessibility. These aspects do not only coincide with blockchain but also PAs, which are purposed to determine policies and deliver various services perpetually to all citizens. As a result of such similarities, this research will focus on looking at blockchain as an II in PA. In this regard, considering blockchains' potential, this study investigates how the technology can be integrated into current infrastructures by looking the current issues holding back PA establishments from moving forward with the technology.

Tensions in Information Infrastructures

A central theme of the IIs literature has been the existence of tensions as a pivotal point of the evolution of any infrastructure (Edwards et al., 2007). The concept of tensions in the context of Information Systems refers to different challenges arising from a divergence in goals, desires, and expectations, which emerges when conceiving and enacting an II (Ribes & Finholt, 2009). There is a variety of tensions recognized in the literature: Hanseth et al. (1996) were among the first to explore tensions, focusing on standardization and flexibility as the main sources of challenges in IIs. Edwards et al. (2007) describes tensions as conflicting forces and summarizes them into three categories, mainly related to time, scale and agency. Tilson et al. (2010) look at tensions in the form of a duality and conceptualizes two main tensions: stability vs. flexibility and openness vs. control. More recent studies such as Bygstad & Hanseth (2016) determine that tensions in an II result from a lack of balance between different stable and unstable elements, meanwhile Lyytinen et al. (2017) study tensions from the perspective of both generativity and evolution.

Nevertheless, whilst the aforementioned studies offer a broad understanding of different tensions, they do not account for a challenging aspect of II: the need to ensure that an infrastructural solution that works today can be enduring enough to put up with the needs of the future. This is a key issue to be taken into consideration for our study as sustainable development and long-run planning are important aspects of any PA. This is why for the purpose of this research, we will focus on the Ribes and Finholt (2009) framework, which examines tensions in IIs based on the concept of "the long now" - which the study uses to describe the friction between present and future demands. In addition, the main focus of this framework is to highlight the tensions emerging during the II development phase, which would be particularly important would blockchain be introduced to current IIs in PA.

Ribes and Finholt (2009) generated a methodological framework, through which they identified nine different tensions, applicable to long-term IIs. As depicted in Table 1, their framework is based on three "scales of infrastructure" – *institutionalizing*, *organizing work* and *enacting technology* – and three main concerns pointed out by stakeholders – *motivating contribution*, *aligning end-goals*, and *designing for use* – reflecting on the sustainability of II in the long run. The three scales are described in Ribes and Finholt (2009) as following: the first scale, institutionalizing, regards the conversion of IIs into sustainable arrangements with consistent and aligned human and institutional resources. The second scale focuses on the human arrangement according to the II and whether the participants are stimulated to continue

working on objectives that are aligned with that particular II. The last scale, enacting technology, regards the way a new technology shifts to become a durable and sustainable resource. On the horizontal axes, aligning end goals regards the conflicting objectives that arise from the existence of different community interests. Motivating contribution describes the commitment of participants involved in effectively contributing to the infrastructure development over time. Lastly, designing for use concerns the creation of infrastructures that the users would be willing to adopt as it would serve their purposes and that would appear to be long-lasting in addressing their needs (Ribes & Finholt, 2009).

	Institutionalizing	**Organizing Work**	**Enacting Technology**
Aligning End Goals	Project vs. Facility	Planned vs. Emergent	Inclusion vs. Readiness
Motivating Contribution	Individual vs. Community	Development vs. Maintenance	Research vs. production quality systems
Designing for Use	Communities vs. Constituencies	Research vs. Development	Today's requirements vs. tomorrow's users

Table 1. Tensions Framework (Ribes and Finholt, 2009)

This framework will be used to assess the adoption of blockchain in PAs, addressing its three scales from the point of view of the actors involved in the potential adoption of blockchain. We will adopt the tensions as a lens for identifying conflicting elements in blockchain adoption, and the tensions in our case could either converge with the ones from the Ribes and Finholt (2009) framework or emerge differently.

Research Methodology

Research Setting

The setting for this research is based on the adoption of blockchain in the Italian PA. Italy provides a significant setting for blockchain adoption given how it has provided a focal point for the Italian government to promote digitalization in the country. In 2018, The Ministry for Economic Development in Italy was among the highest instances to promote blockchain by creating a group of 30 high-level experts to draw a national strategy based on this distributed ledger technology. In 2020, Italy was the first country to commission an OECD report on the blockchain application highlighting how the technology has the potential to enhance further

the digitalization of different sectors and provide a series of opportunities for business developments in the country (Bianchini & Kwon, 2020). The following year the Blockchain Innovation & Solutions Hub was created with the sole purpose of promoting and facilitating blockchain based projects in the country. In addition, since 2019 Italy has its own statutory definition of blockchain and national law regulates the use of blockchain and smart contracts in deals and procedures (Senato della Repubblica, 2019).

Such important initiatives fall within a recent shift in Italy to embark on more e-government projects and implement a stronger digital agenda in an effort to make public services more accessible and reliable (Battisti, 2020). In this regard, studies show that such goals alongside the need from an infrastructural perspective to increase the level of privacy and security in all PA services in Italy could be addressed by blockchain technology (Dell'Era, 2022). Additionally, Italy has signed with Europe an important partnership about blockchain adoption in cross-border digital public services (European Commission, 2018). Nevertheless, the extent to which blockchain has been implemented in PA has been very limited and many projects have been short-lived in terms of application. This is why our research is centered around the main themes that public decision-makers identify as challenges related to blockchain, such as: governance model, impeding factors, resistances, change in roles and behavior (Cagigas et al., 2022). We look at these challenges as tensions evidencing the different expectations and inclinations that public decision makers have towards them.

Data Collection and Analysis

For the purpose of this research, a qualitative study with an interpretive approach was employed, which is considered to be a well-established methodology in the domain of Information Systems research (Walsham, 2006). Such a method allows to gain a better understanding of the varying experiences and beliefs different individuals can have on a phenomenon despite the similar setting (Klein & Myers, 1999). In doing so, primary data consisted in a set of semi-structured interviews conducted with key decision-makers in PAs. In addition, secondary data were gathered from multiple sources including panelists' talks, observations, and different government documents and publications concerning blockchain adoption in Italy.

A total of eleven interviews were eventually conducted by senior researchers, using a semi-structured track, mainly focused on seven macro-themes all referring to blockchain: Level of knowledge, Blockchain experiences in the administration, Areas and Types of use, Changes, Difficulties and Resistances, Risks, Configuration, and Technical choices. As interviewees, we

chose individuals in key positions – such as, Assessor to Innovation, CIOs, General Directors and Project Leaders – who, within their jurisdictions, had either made decisions on the adoption of blockchain technology within their respective PA settings or were considered to have direct knowledge because they had been already part of different initiatives involving blockchain in the public sector. Considering the still recent emergence of blockchain in the PA domain, we deliberately decided to turn to large PAs and/or those already known for having experienced some form of blockchain adoption. In order to mitigate any potential limitation and ensure variation given that the data would focus on a single country, the interviews aimed at encompassing the perspective of individuals who work in an array of different PA institutions, in different regions, having different sizes and hold different roles within these establishments. Table 2 depicts a brief summary of the job titles, and the type of PA participants were serving at the time of the interview.

JOB TITLES/ROLES OF THE INTERVIEWEES	
Description	**Number of Interviews**
▪ Director	4 interviews
▪ IT/Innovation Councilor	2 interviews
▪ General Director, Coordinator	2 interviews
▪ Head of Project	1 interview
▪ IT Communication Expert	1 interview
▪ Archive Management Expert	1 interview
TYPE OF PUBLIC ADMINISTRATION OF THE INTERVIEWEES	
Description	**Number of Interviews**
▪ Central Administration	4 interviews
▪ Big municipality	3 interviews
▪ Region	2 interviews
▪ Other	2 interviews

Table 2. Interviewees' Characteristics

Subsequently, after the completion of the interview campaign, two of the authors attended a panel discussion consisting of talks and a question-and-answer session, with 6

experts and top decision-makers from different PAs in the country. During the discussion, the implementation of blockchain in the PA in Italy was argued in extensive details for over 2 hours and the main emerging themes were considered in accordance with the results from the interviews. Lastly, in an effort to gain a broader understanding of the topic, secondary data sources including analysis of authoritative reports from governments, policy overviews, press releases and country analysis relevant to the study and blockchain were also analyzed.

Once transcribed, the interviews correspond to more than 28,600 words. After the transcription, the interviews' texts were coded with the support of NVivo, which is a renown data analysis software used for facilitating the organization and classification of data (Jackson & Bazeley, 2019). To ensure reliability and rigor in the coding, the process was performed separately by two researchers (Gioia et al., 2013). The researchers would afterwards compare their work until achieving consensus on the emerging themes from the analysis. The transcriptions were coded in two rounds: In the first round, the researchers focused on identifying through inductive reasoning any emerging challenges. The tensions often were not directly named as such by our interviewees but were rather underlined as frictions or difficulties. Through an interpretative thematic analysis, these frictions emerging from the interviews and from the panel of experts were then classified by the researchers as tensions. Lastly, in the second round of coding, the identified tensions were aggregated into the distinct categories that make up our framework.

Emerging Tensions

In this study, interviewees recognized a number of difficulties in the context of blockchain implementation in the PA based on their personal experience with the technology. Despite the adopted framework by Ribes and Finholt (2009) encompasses a broad perspective on tensions, it is interesting to notice how, based on our findings, the emerging tensions from the analysis manifest themselves differently. We estimate this to be due to the specificity of the context and to the nature of the II considered here. In this section, the nine tensions emerging from the analysis are detailed and organized in three scales of infrastructures as depicted in Table 3.

	Institutionalizing	Organizing Work	Enacting Technology
Aligning End Goals	*Decentralization vs. Control* Manifested as concern with regard to the type of architecture, governance and administrative body behind the blockchain network	*Fearing vs. Embracing Change* Observed as a conflict between traditional ways of working and operating in PA and blockchain as a novel way of conducting day to day work	*Change Management vs. Readiness* Evidenced as a conflict between willingness to adopt blockchain and "fear" of wasting the technology due to lack of readiness in managing it
Motivating Contribution	*Local vs. General Interests* Observed as a divergence in goals 1) between a PA and central government, and 2) between a PA and the general community of individuals working in it	*Needs vs. Wants* Manifested as a potential lack of balance between a purposeful infrastructure that meets the PA wants versus the user needs	*Paper vs. Practice* Emerges as a challenge to meet in practice the necessary expertise and knowledge needed to operate blockchain
Designing for Use	*Standalone vs. Interoperability* Emerges due to lack of interoperability stemming from different practices and technologies between different authorities operating on the same service	*Adoption vs. Adaptation* Evidenced as a conflict between the mere adoption of blockchain as an II and being able to adapt the work to match such adoption	*Hype vs. Sustainability* Manifested as continues uncertainty on whether blockchain is a sustainable technology able to also address future needs or just a momentary trend

Table 3. Summary of tensions in blockchain-based Information Infrastructures in PA

Institutionalization

Decentralization vs. Control (Institutionalizing and Aligning End Goals)

Participants show concern regarding the architecture and governance of blockchain that would be implemented and the administrative body behind it. Several interviewees emphasize the fact that a blockchain adopted by a PA should be run and managed in a network of PAs' nodes, so that the control can fully remain in the public sphere and the same regulations are applied to all parties in the network. No private entity should be in charge of administering the network in order not to lose the fully public control of the blockchain. Third-party control may introduce the risks of lowering the reliance on the integrity of data and limit the compliance to

data privacy regulations, a risk that can increase if a third private party is acquired by a company based on a state with different privacy regulation.

"I believe that very delicate issues are related to privacy: exposing the blockchain generates risks, which can become even greater in the case of entrusting the management to a private entity, which could perhaps end up owned by a non-EU entity. A similar case is that of the SPID [ed: one of the Italian systems of digital identity], *whose management has been entrusted to private providers."*

Local vs. General Interests (Institutionalizing and Motivating Contribution)

This tension emerges as a quarrel between a single PA adopting blockchain and a more influential governing body which oversees PAs, such as the central government. The individual needs of specific PA institutions do not necessarily match the ones that would support the policies of higher level governmental agencies; therefore, a tension emerges. The interviewees make several references on how PA is very tightly linked to politics, and more specifically to elections, which appear to have a central impact in the political decision-making regarding the adoption of technologies of this caliber and influence. Given how local governments are not fully independent in deciding over the adoption of an impactful II like blockchain, even when they evaluate the technology could provide a positive revamp to their services, local authorities would still require looking for aligning with central government on the matter.

"*Last year, just after the elections, we didn't know what government there was going to be in power, there was a period of darkness we didn't know how things would go on. Unfortunately, my fellow directors decided not to do anything, saying: 'we don't know what government is coming, then maybe things will be different afterwards'*".

Moreover, the hesitancy in adopting blockchain also manifests as a tension between the local needs and the state's ambition in embracing new technology. In this regard, public decision-makers, who besides efficiency should take care of the community, are very much concerned about the aftermaths of blockchain adoption.

"If this technology would help reduce the burden on people, it means I reduce the workload by introducing the blockchain. What will be the consequence? The consequence is that I need fewer people, and the job offer will be reduced."

Standalone vs. Interoperability (Institutionalizing and Designing for Use)

Despite different establishments, such as municipalities, regional departments and public agencies being all part of the PA as a whole, there might be tensions arising from the possible difference in their focus or in the consolidated habits in which they operate. The tension emerging in this case is evident between a central control and local practices or between different authorities that operate together on the same service. In this case, a singular service can have different authorities but interoperability in this regard has proven to be poor and lacking between institutions, especially from a technological perspective. For instance, an example given by our interviewees is the driving license, which has a complicated trajectory from an administrative and governing perspective when being issued or in case of being given traffic ticket points in light of specific violations from different governing bodies. When all these subjects have to work together in sharing information, the level of interoperability between their IIs is not always efficient, with each constituent body preferring on working ensiled and independently.

"*We're talking about a multilevel system, an interconnection system only it's completely siloed, and it's done in a paper way."*

Organizing Work

Fearing vs. Embracing Change (Organizing Work and Aligning End Goals)

To evidence this tension, we can refer to a successful, yet aborted, blockchain initiative from one of the Italian municipalities regarding schoolbooks vouchers that are given to individuals who have an income below a certain predefined level. The traditional trajectory to be eligible for such a voucher was to apply a request to the municipality within the 28th of April every year. After that, a long manual process of evaluating all applications started. This procedure was built on several pieces of software, but the list of eligible names could be potentially altered along the trajectory, by manually adding new names to the list after the

official deadline by clerical offices. By applying blockchain to the online system, once the date hits the 29th of April, the system would be locked and not accept further applications whilst the people eligible would be automatically sorted based on the predefined list of requirements. This would allow not only a speedy procedure execution, but it would also avoid any possibility of favoring anyone or accepting applications after the deadline. Additionally, any single transaction would be certified and could be easily inspected if so requested. In this case, blockchain proved to be successful in guaranteeing a fair and equal service but the same interviewee underlines the fact that, whereas the schoolbook vouchers offered a favorable space for the implementation of blockchain, other involved departments in the same municipality did not prove equally welcoming to implementing blockchain in their line of work because of their fear of changing, which resulted in the abandonment of the project altogether.

"In the case of the schoolbooks voucher there was a favorable environment for introducing it [ed.: blockchain innovation]. *It has to be said that it isn't the case for all departments. Not because there are scams or cheats or special interests, but because there is a fear of change. If one thing has always been done this way, then this is how we should keep doing it."*

Needs vs. Wants (Organizing Work and Motivating Contribution)

This particular tension highlights the importance of stability by creating a well-defined balance between a good, technology-fit and purposeful infrastructure and the fact that it should be also practical and match the needs of different users. Despite the technical work being an essential element when developing a new or existing infrastructure, it is also important to keep in mind the end users and be able to answer their exigencies. Subjects participating in the interviews show disappoint about the fact that, albeit promising results, the blockchain-based projects they had been associated with eventually short lived and not extended further. In some cases, the reason for that was because most of the focus regarding blockchain was being put on expected benefits based on the goals of PAs, rather than on the user needs. Most of the interviewees refer to significant blockchain-based pilot tests that they had undergone, but despite the positive results, there were hesitations in proceeding with the deployment on a larger scale, given the lack of strong evidence about blockchain being able to match the needs of all the stakeholders, including users.

Particular to this issue, it is interesting to mention the introduction of design thinking

processes that at least one of the interviewees mentions to have initiated as a way of addressing the aforementioned challenges. Such initiatives seem particularly important since, apart from understanding the assumptions citizens have regarding blockchain, they could also voice their needs and problems that could be potentially addressed during the wider adoption of blockchain. These round-tables would be inclusive of all stakeholders and results seem promising.

"We are very happy about the design thinking and its first results. As prescribed by the design thinking methodology we have involved all stakeholders, including citizens. We are so far satisfied by the results, which is why we will continue this line of work."

Adoption vs. Adaptation (Organizing Work and Designing for Use)

The adoption of blockchain in the PA would need to encompass an enduring II that would sustain different work processes and practices. In order for this to be maintained, the well-functioning of the infrastructure is to be supported with adaptations made to the day-to-day work, which in many cases is disregarded as an important factor leading to a successful blockchain adoption. Our interviewees note that the adoption and later continuous adaptation of a blockchain-based infrastructure are two very different matters. Whilst the interviewees recognize how the technology offers a series of benefits, they also stress the fact that it comes with a series of changes and adjustments that should be made to suit the new system.

"Blockchain gives you integrity but does not keep the document for you which is your job. It saves the hash that certifies the document, but not the document; the latter being your job."

Enacting Technology

Change management vs. Readiness (Enacting Technology and Aligning End Goal)

There is a social and administrative problem associated with the adoption of blockchain, which relates to the fact that it is still a new technology. Many interviewees repeatedly claim that it exists what they call an "unpreparedness of PAs" on different spectrums, ranging from organizational attitude to culture inclination to change. Evidence is

given that some PA body had initiated the implementation of blockchain but had later been forced to halt any further advancements. The reason behind this decision stemmed from the awareness that they would have failed early after, given the limited expertise and lack of technology readiness of the inner circle of stakeholders within the PA establishment. Other blockchain-based initiatives appear to have stopped to a more advanced stage, because the decision-makers did not wish to "waste" the technology in a domain which is not ready in welcoming such a technology.

"*We have a blockchain project that we had to halt the introduction of the technology at the moment because the blockchain is a beautiful technology, but we risk burning the technology if the organization is not ready*."

Additionally, the interviewed experts state that, before actually implementing blockchain, a redefinition should take place of internal processes and administrative mentality in order to fit that of blockchain. Participants do not consider the technology itself to be the main issue in this regard, but rather the current administrative culture, which seems not very accepting of changes.

"Blockchain is above all an issue of evolution of society, it is less a technological aspect but more an aspect of social change."
"We have no concerns about the technology, but we do have concerns about the PA organization that can reap the benefits of this technology."

Paper vs. Practice (Enacting Technology and Motivating Contribution)

Tensions in this quadrant are manifested due to difficulties in introducing blockchain in practice, notwithstanding its perceived technological value. In a large municipality in northern Italy, from the operational perspective, many blockchain initiatives have not been fully developed because of the lack of experts able to set off and operate blockchain in the specific domain of PA, with its rules and processes. The lack of proper knowledge requiring more than just technical skills would have later led to halt further developments with blockchain. Moreover, the implementation of blockchain is at times challenging, because of issues related to other accompanying technologies.

"We did not witness any difficulties with blockchain itself but noticed different issues with parallel technologies."

User experience from the perspective of citizens may also be very important whenever blockchain makes transactions and processes more difficult. Nevertheless, many participants noted that in the cases where blockchain had been actually implemented, the technological aspects of blockchain did not manifest any issues. Despite being trivial, participating experts recognize also that the lack of internet or poor internet connection for instance would make transactions more difficult, but this is unrelated to blockchain and the challenges were mostly reflected in terms of operators rather than end-users.

Hype vs. Sustainability (Enacting Technology and Designing for Use)

The needs of the users are ever changing and therefore, for any new technology that has been developed and later deployed, there is the continuous need to make it long-lasting by matching it not just to the current requirements but also to future necessities. What is interesting to notice in the case of blockchain adoption in the PA, is the fact that this tension is primarily evidenced in the lack of adoption of blockchain, because according to some interviewees today's requirements can easily be addressed through the current technologies, without the need to go through the complicated path of developing a new infrastructure.

"We see the blockchain with a skeptical eye when it is proposed as the technology that offers impermeable data chains. There are other systems that cost less which we have adopted for administering documents, and which ensure comparable results."

It is worth noticing in this regard, that in some cases, the same public decision-maker who chooses to continue working with existing technologies was one of the pioneers in exploring and experimenting with blockchain in the PA some years back, before deciding to suspend the projects due to the aforementioned concerns.

Discussion

First and foremost, despite the emerging tensions thereafter, most of the participating experts agreed about the large potential of blockchain. They recognize how blockchain has the

right characteristics for a game changer that could influence the organizational structure, culture, and processes within an organization. This is consistent with the series of scholarly articles analyzed, which also highlight a scholarly consensus on the advantages of blockchain the PA realm with regard to carrying more efficiently various public services (Ølnes et al., 2017; Berryhill et al., 2018; Batubara et al., 2018; Cagigas et al., 2021). Nevertheless, despite such positive outlook on the blockchain technology, all the interviewees agreed that in the context of PA, there are a series of challenges that prevent a wider adoption of blockchain technology. In this section, we discuss and evaluate such challenges that we previously mapped in the form of tensions with reference to the various contexts resulting from the related literature, in an effort to reveal the main key inferences from this study.

The set of tensions emerging in the first infrastructural scale, institutionalization, manifest mostly in terms of issues stemming from having to align the needs and possible competing priorities of different stakeholders. Firstly, there was genuine concern with regard to who should run and manage a blockchain II and whether the introduction of a private entity would be imminent to administer the network of nods in the PA. Such a tension corresponds to the need to pick the right type of blockchain to be implemented in terms of architecture and governance. This tension converges with Tilson et al., (2010) paradox between openness and control as continuous conflicts evident in the evolution of IIs. The issue is also in line with an important stream in IS research that underlines the importance of architecture and governance in the development of infrastructures (Henfridsson & Bygstad, 2013; Tiwana, 2014). Finding the right balance in terms of architecture and governance in light of multiple interdependencies between actors, such as in the case of different PA organizations, is considered key in transitioning to new infrastructural configurations (Constantinides & Barret, 2014). Nevertheless, as noted in literature, blockchain technology has now evolved past first-generation blockchain into various types in terms of permission and consensus mechanisms that can fit different requirements and dispositions (Yang et al., 2020; Zhang & Lee, 2020), which can aid PA in addressing this tension.

The second tension in the institutionalization column makes reference to the possible divergence in focus between particular PAs and central government when it comes to blockchain adoption. A similar tension has also been highlighted by Bygstad & Hanseth (2016) work on II that points out at issues originating from a divergence of objectives between top down governance regimes. Nevertheless, while political agendas are expected to differ, our research shows that more and more governments are pushing policies towards recognizing blockchain and supporting blockchain-based initiatives in various sectors (Batubara et al.,

2018; Biswas & Muthukkumarasamy, 2016; Bhushan et al., 2020). While the number of emerging technologies has been soaring in unprecedented rates, not all technological trends are long lived. Despite this, in the case of blockchain, studies show that the number of government-initiated blockchain projects associated to public services continues to be in the limelight (Cagigas et al., 2021), which is indicative of how blockchain is a powerful technology that is here to stay. Lastly, the third tension under institutionalization indicates possible challenges that can stem from lack of coordination and interoperability between different PAs. Pluricentric coordination in public governance is a distinct characteristic to be expected, but it is surprising to be noticed in the case of blockchain for two reasons. The first reason being that the implementation of blockchain is considered to be a powerful tool in facilitating transparent and secure data sharing between different government institutions (Ojo & Adebayo, 2017); and secondly, because literature shows that blockchain can play an important role in increasing interoperability between different institutions (Moura et al., 2020; Spahiu et al., 2022). A possible solution to consider in this case could be the creation of blockchain consortia able to balance the existence of various differences by allowing organizations to leverage blockchain without giving up their own specific needs (Dib et al., 2018).

The second set of emerging tensions related to the organizing work scale, is associated to issues originating from factors internal to the PAs. While differently manifested between them, the main idea generated from these three tensions is that whilst PAs recognize the potential of blockchain technology and would be willing to test it further, distinct fractions inside the PAs are hesitant to move forward. As shown from the analysis this hesitancy can derive from a possible fear of embracing new technology and a strong duality between current needs and future wants. A similar tension has been expressed in Edwards (2007) work, which points out how the fact that when established actors owe their status and power to current II this can make them more hesitant to any replacements or changes imposed to the present infrastructural arrangements. The set of tensions under organizing work are also in line with previous studies concerning PA that highlight how the adoption of new technologies in this domain can trigger various organization changes that are not always welcomed (Dunleavy et al., 2006; Shava & Hofisi, 2017), especially due to the fact that public officials are very risk-adverse and thus resistant to change (Buurman et al., 2012; Cagigas et al., 2022). More specifically with regard to blockchain, recent research has shown that blockchain perception from internal actors can have a direct effect on their attitudes towards the technology (Cagigas et al.,2022). And given that blockchain is a recent technology, blockchain literacy is expected to be limited. In order to address such tension, PAs could put more effort in informing relevant

actors on the potential of blockchain to improve existing infrastructures in the public domain (Ojo & Adebayo, 2017; Farouk et al. 2020) and whose properties could be expected to create new global IIs rooted on trust and security (Avital et al., 2016; Beck et al., 2017; Constantinides et al., 2018).

The last set of tensions, pertaining to enacting technology, make reference mostly to the operational challenges associated with the blockchain technology. It appears from the findings that most PAs express concern with regard to the lack of guidance and expertise on how to operate a blockchain network, which leads PAs to be hesitant in adopting blockchain in an effort not to "waste" the potential of the technology. From an operative perspective, it appears as critical the imminent need for more qualified personnel to guide PAs through the adoption of the right blockchain and aid them in operating it thereafter. Such findings match other studies citing how the fact that blockchain is a new technology and therefore expertise in PAs is limited (Hyvarinen et al., 2017; Navadkar et al., 2018) and successful training is challenging at a national level (Cagigas et al., 2021). Lastly, a final tension emerging from the findings underline the concern that, from a practical point of view, blockchain does not offer cutting-edge benefits enough to go through the trouble of replacing current infrastructures. Nevertheless, studies in this regard indicate that blockchain offers a series of advantages leading to higher security, reliability and immutability of transactions records (Iansiti & Lakhani, 2017; Vella & Gastaldi, 2021; Spahiu et al., 2022), which have proven to lead to elevated transparency, auditability and reduction of fraud (Ali et al., 2021; Frizzo-Barker et al., 2020; Saheb & Mamaghani, 2021). Again, this could suggest that more efforts should be placed towards proper education of relevant stakeholders in fully understanding the potential of blockchain through appropriate case studies showcasing successful adoption and associated benefits of such adoption.

Contributions and Implications

Implications for Research

Our research makes several theoretical implications. Firstly, this study argues how blockchain technology converges with the properties characterizing Information Infrastructures and in doing so extends the concept of blockchain-based II in the public context. Hence, it contributes to the emerging research linking IIs in light of forefront technologies such as blockchain (Ølnes, 2016; Jabbar & Bjorn, 2017; Ojo & Adebayo, 2017; Ølnes & Jansen,

2018). By looking at blockchain from the lens of II, we have been able to address the various calls in literature voicing the need to look at blockchain through different models, as the only way to understand and embrace this technology (Ølnes et al., 2017; Pelt, 2021).

Moreover, we find that blockchain-based IIs are shaped by tensions, which relate to the technical, operational, behavioral and cultural strains that impact the adoption. We see how in the PA domain these constrains wrestle against the different dynamics that would follow internal processes when a blockchain adoption takes place. The findings stemming from this research push therefore for the broadening of the blockchain research agenda to look beyond the technical aspects, rather focusing on challenges as social and organizational patterns that can aid in understanding better blockchain adoption (Zheng et al., 2018; Monrat et al., 2019). Consequently, as part of action research, this study offers the possibility of investigating and ultimately influencing the creation of potential policies addressing the tensions presented in this study.

In addition, through our findings, we extend the Ribes and Finholt (2009) framework to adapt it to the tensions emerging from the specificities of a context different from the one they studied. On the one hand, this reflects to the challenges that the nature of potential new IIs sets forth. On the other hand, it provides a multi-modal perspective on IIs that must be understood better in order to have a better perspective on the evolution of IIs in the midst of new developments.

This study also offers an ample opportunity for new research in various fronts. Given how this research is based on evidences gathered from PA in one single country, future research could investigate whether the findings resulted in this paper would apply to other settings and countries. In case of dissimilarities, it would give the opportunity to reflect on the possible differences and reasons behind heterogeneous results. Additionally, with regard to future research, the use of the tensions as a lens to investigate the adoption of blockchain in PAs' IIs opens the door to new studies that could investigate large-scale implementations of blockchain-based IIs to see how tensions have been confronted and resolved in real organizational contexts. In this regard, it would be interesting to see how managers address such tensions and it also would offer the opportunity to see the role played by different contexts within PA.

Finally, similar to this line of work, it would also be interesting to verify if the tensions observed in the PA would also apply to the blockchain adoption in other domains not related to PA. In this regard, studies so far have mostly looked at challenges related to blockchain as a mere novel technology. Therefore, future research could extend this line of work investigating tensions in blockchain-based IIs in other domains outside the PA, in an effort to

understand how they compare and contrast under distinct circumstances.

Implications for Practice

Being able to identify at an earlier stage the tensions that are more evident in blockchain adoption, would make it easier to assign possible solutions to potential challenges and avoid possible pitfalls before development. In turn, addressing such tensions would allow for a successful integration of blockchain in PA IIs. Based on the vertical and horizontal axes in our framework such integration should be expected to entail aspects related to structures, practices and culture, which require alignment, engagement and user centricity. Consequently, professionals can benefit from identifying the tensions and making risk considerations before embarking on a blockchain transformation process, which would allow for PAs to leverage better the technology. In this regard, from the analysis of the interviews conducted and based on the main emerging findings, three main practical implications could be derived.

Firstly, what appears to be important is the need to pick the most appropriate blockchain in terms of governance and architecture model. This is an important aspect given the sensitive nature that constitutes the work carried out by PA. In addition, this is a key element that offers the opportunity to solve any interoperability issues currently evident between PAs, which in turn might also be impeding blockchain adoption as well.

Secondly, addressing the current administration culture appears to be an eminent step to successfully integrate blockchain to current infrastructures. A cultural shift consisting of setting a new administrative mindset that embraces new technologies, would make it easier for blockchain to be accepted and adopted. In this regard, it would also be important to educate all affected stakeholders on the potential of blockchain, how it works and how it can be integrated for the better to current practices, without having to necessarily put at risk present jobs.

Lastly, it is important to determine from an earlier stage the operational side of blockchain. With reference to this issue, emphasis should be put to the technical and functional competencies that must be acquired in order to operate and maintain a blockchain based infrastructure during the development phase and thereafter.

Conclusion

Blockchain is an important decentralized ledger whose characteristics have showed great potential in a variety of domains. However, successful large-scale adoption in particular areas such as Public Administration remains limited, which led us to question: “How can

blockchain be integrated into PA infrastructures?". In order to address such question, we bridge the notion of blockchain with Information Infrastructures, by comparing the common characteristics of the two and subsequently investigating the main challenges in terms of tensions that are widely considered in Information Systems literature as an integral cornerstone in understanding the evolution of IIs.

This research extends existing literature regarding blockchain adoption in PA by highlighting from the perspective of reality the main challenges and current limitations associated with this technology, as evidenced by our interviews with key decision-makers in PAs who had already considered or experienced blockchain adoption. Our findings suggest the main tensions are manifested as ongoing concerns related to, on the one hand, the complex nature of PAs and how they operate internally and, on the other hand, to the distinct characteristics of blockchain and how it can be accurately managed as a new technology. The outcome of this research can be expected to be useful for decision-makers in anticipating the main expectations associated with a possible blockchain adoption and address in advance any potential issues.

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CHAPTER 3

Blockchain and Polycentricity: An Architecture and Governance Configuration Perspective [5]

Abstract

The recent proliferation of blockchain has seen an increase in applications in various fields, due to its specific features that make blockchain a technology often associated with a new era in Information Systems. Despite the increasing number of blockchain use cases, the mechanisms explaining the successful implementation of blockchain-based solutions are still limited in scope. In this paper, we showcase how the specific architecture behind blockchain and polycentricity as a governance model, interact and shape the successful implementation process of a blockchain-based solution. Our findings are based on interviews conducted with various key actors of a well-established financial organization recently embarking on the implementation of blockchain as means of achieving digital transformation. Findings suggest polycentric governance stemming from a multitude of stakeholders, specific norms and efficient leadership can play an important role in the implementation of blockchain - whilst the blockchain architecture was found to be equally efficient in tackling the "tragedy of the commons" which polycentricity has often aspired to resolve. To demonstrate the symbiotic relationship presented from this interaction, we adopt the Architecture-Governance configuration model as articulated by Hanseth and Modol. Furthermore, we explain our main findings in terms of governance configurations, artifacts, heavyweight and lightweight IT given their unfolding as principal themes from the analysis of the findings.

Keywords: Blockchain, polycentricity, A-G configuration, digital transformation, artifacts, heavyweight and lightweight IT

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Introduction

In the recent years, blockchain technology has shifted from being an elemental feature of Bitcoin, into enjoying a wide adoption in different domains outside cryptocurrencies (Labazova et al., 2019; Bodkhe et al., 2020). Blockchain is extensively spreading as a superior option in delivering various services that would benefit from its distinctive qualities, such as immutability, transparency, security, and efficiency (Pilkington, 2016; Ismail & Materwala, 2019). Blockchain comprises of a digital ledger that is based on a distributed system consisting of a network of blocks connected with one another creating a chain of every transaction performed, subsequently offering the opportunity to reimagine the way transactions are managed, stored, and distributed (Nofer et al., 2017; Syet et al., 2019). The technology proposes a new approach to establishing trust by means of consensus protocols and cryptography (Hawlitschek et al., 2018). Blockchain has been experimented upon a series of prominent uses that vary from supply chain and cross boarder payments to e-government and smart cities in an effort to digitally transform current practices and perspectives (Chen et al., 2018; Saberi et al., 2019; Spahiu et al., 2022).

Nevertheless, despite the increase in number of applications, many initiatives remain short-lived, and more case study based and result oriented research regarding the successful implementation of blockchain is required (Rossi et al., 2019; Treiblmaier, 2020). In addition, what is noticeable in this regard, is that most studies on determinants of blockchain implementation only focus on technological factors, key stakeholders and regulatory frameworks (Reddick et al., 2019; Balasubramanian et al., 2021). There is a noticeable absence of research defining the role of organizational governing models and institutional frameworks in blockchain adoption. With regard to governance, studies have been limited mostly to looking at the control mechanisms for enforcing blockchain networks and the novel models of governance associated with the technology in terms of decentralization and power distribution (Beck et al., 2018; Pelt et al., 2021; Lumineau et al., 2021). We address such limitations in literature and the call for more result oriented research by looking at the successful implementation of a blockchain based solution through the lens of architecture and governance configuration model in an effort to understand how a decentralized system like blockchain interacts with particular governance models such as polycentricity, eventually leading to an efficient digital transformation.

The objective of this study is therefore two folds: Firstly, it aims at highlighting the

role that governing structures play in the successful implementation of technologies such as blockchain. In this regard, there has been empirical evidence suggesting a polycentric approach can have positive implications towards the adoption of technological innovation as it aids specific modes of coordination between networking actors (Dühr, 2005; Gatzweiler, 2016; Miller et al., 2020), which would be interesting to be explored further in view of disruptive technologies such as blockchain. Secondly, this study seeks to extend the current understanding of polycentricity in light of decentralized architectures and how the latter can further address the "tragedy of the commons", which polycentricity is frequently associated with. The tragedy of the commons concerns collective action issues regarding the exploitation of common pool resources when given unlimited and unregulated access to (Hardin, 1968; Ostrom, 1994; McGinnis, 2011). In this regard, research has strived for years to showcase the positive impact that specific cooperation and interorganizational arrangements pertaining to polycentricity can have to address this social issue without the need of centralized control (Ostrom, 1973; Ostrom, 2008; Aligica & Tarko, 2012). Therefore, considering the decentralized nature of blockchain, the technology could provide a new avenue for addressing the tragedy of the commons in connection with polycentric governance. Subsequently in light of these considerations, the research question put forward by this study is the following: "*How can a blockchain based architecture combine successfully with a polycentric governance system?".*

For the purpose of this research, we focus on a recent case study of a financial institution of an important intergovernmental organization implementing blockchain to support one of its main services. We conducted in-depth interviews with the key actors engaged in the implementation process of the blockchain-based solution. In studying the relationship between decentralized IT architecture and polycentric governance, we will draw upon the Architecture and Governance (A-G) configuration model developed by Hanseth and Modol (2021) to explain the complex and intrinsically related association between the two constituents. We illustrate the main results stemming from the interviews and secondary sources through a thematic analysis of the data, which we group in subsets pertaining to emerging themes related to governance and architectural configurations respectively.

This research provides various contributions. First, we document the successful blockchain implementation addressing the need for more result oriented studies. In doing so, we detail the important elements that lead to a positive outcome in terms of the symbiotic relationship between architecture and governance. The results from this study demonstrate how the implementation of a decentralized architecture can successfully address collective action problems and assist in the emerge of a polycentric governance system. Secondly, our analysis

showcases how specific governance models such as polycentricity can play an important role in blockchain implementation leading to a successful digital transformation, which offers a new perspective on studying emerging technologies such as blockchain in light of different governance settings. Thirdly, from a practical point of view, we offer insights to innovation managers on how to leverage blockchain-based solutions for digital transformation, in addition to providing a roadmap to how to address some key potential issues associated with the technology based on the main elements stemming from this research.

Literature Review

Blockchain-based digital transformation

The blockchain technology consists of a decentralized ledger able to register accurately every transaction made in a specific network of blocks (Hawlitschek et al., 2018). The block size and dimension of transactions determine the number of transactions that can be recorded in one block (Nofer et al., 2017; Ismail & Materwala, 2019). All blocks are chained with one another through cryptographic mechanisms that make access and manipulation of the records virtually not feasible (Kosba et al., 2016; Hawlitschek et al., 2018). Blockchain offers the opportunity to have a digital record of transactions over multiple user servers that can be verified from all the participants in the network. In addition, the technology removes the need of a middleman (Nofer et al., 2017; Pilkington, 2016; Syet et al., 2019), overcoming therefore issues related to third-party intermediating processes (Zachariadies et al., 2019; De Filippi et al., 2020). Whilst most of the traditional databases have some kind of centralization, blockchain allows equal participation to all nodes, which offers a new perspective to ownership and access (De Filippi et al., 2020). Being a distributed technology, it also addresses any single point of failure issue, which in turn reduces the possibility of a downtime in case of any possible system collapse (Bodkhe et al., 2020). Moreover, the transactions are considered immutable and unable to be tampered once they are registered on the blockchain and everything on the network would be visible to every party involved, which offers an alternative way of establishing trust (Hawlitschek et al., 2018; Angelis & Da Silva, 2019). In this regard, blockchain has also given an innovative outlook to business relationships and the establishment of trust between distrusting parties (Tapscott & Tapscott, 2017; Angelis & Da Silva, 2019). This has resulted in a new revolution in the way organizations interact through more transparent, efficient and secure decentralized platforms (Malhotra et al., 2022).

Whilst the technology was first introduced as the backbone of Bitcoin, more than a

decade after, blockchain applications have seen a wide range of domains that go far beyond its primary purposes (Chen et al., 2018; Labazova et al., 2019; Bodkhe et al., 2020). Blockchain was initially adopted in the finance sector where it proved useful in digital assets and online payments (Tapscott & Tapscott, 2017; Treleaven et al., 2017). Nevertheless, in the last years the rate of adoption of blockchain has increased. The utilization of blockchain has been leveraged in a variety of areas such as public services (Cagigas et al., 2021; Spahiu et al., 2022), financial services (Tapscott & Tapscott, 2017; Treleaven et al., 2017), healthcare (Hölbl et al., 2018; McGhin et al., 2019; Farouk et al., 2020), education (Skiba, 2017; Bhaskar et al., 2020) and supply chain (Francisco et al., 2018; Azzi et al., 2019; Queiroz et al., 2020). Subsequently, blockchain is quickly becoming one of the most promising technologies leading to a dramatic revamp of how transaction processing systems are conceptualized (Nofer et al., 2017; Puthal et al., 2018; Syet et al., 2019). Additionally, the main characteristics of blockchain consist in offering both decentralization and auditability, which has turned blockchain technology into a very compelling digital tool able to address fraud and security challenges alike in various sectors (Pilkington, 2016; Ismail & Matewala, 2019; Schmitz & Leoni, 2019).

The many benefits associated with blockchain have also offered new prospects for the technology to enable and enhance digital transformation (Rot et al., 2020; Dokuchaev, 2020; Bhatti et al., 2020; Kirbac & Tektas, 2021). Digital transformation consists of applying digital capabilities to processes that amplify efficiency (Berghaus & Back, 2016). This converges with the ability of blockchain to alleviate various process inefficiencies in terms of time, automation, costs and human error (Hughes et al., 2019; Spahiu et al., 2022). As an integral supporter of digital transformation, digital infrastructures are also an important domain where blockchain is being exploited. Digital infrastructures today are becoming more and more integrated and interconnected, which puts them at higher risk for unexpected incidents and requires them to be more resilient in terms of security (Sommerville et al., 2012). Such infrastructures are mostly being influenced by how IT solutions are developed and there are two main factors contributing to that phenomenon: heavyweight and lightweight IT (Erl, 2015; Bygstad, 2017). Heavyweight IT relates to the traditional system and database that requires advance integration to be developed (Rosen et al., 2008; Erl, 2015). Lightweight IT on the other hand, relates to a technological solution that requires less integration, can be conducted by IT professionals and offers easier and more accessible IT, such as in the case of “apps” (Alemdar & Ersat, 2010; Bygstad, 2017). Also in this regard, blockchain has offered new ways of progressing both heavyweight and lightweight IT operations by offering alternative solutions of enhancing them (Ismail et al., 2019; Dhanda et al., 2019).

Different configurations of blockchain varying in terms of architecture and consensus mechanisms have made the technology adjustable to various requirements where blockchain can be tailored to fit specific organizational demands (Guegan, 2017; Zheng & Lee, 2020). Nevertheless, despite the pledges made by the blockchain technology, it should not be considered a silver bullet and as such should be handled cautiously. This is why sharing success stories behind blockchain implementations is important in offering a guided map of the process involved (Rossi et al., 2019; Treiblmaier & Sillaber, 2020). Most of the research so far regarding adoption factors leading to a successful implementation and the readiness assessments for implementing blockchain focus predominantly on technological factors, key stakeholders and regulatory structures (Reddick et al., 2019; Balasubramanian et al., 2021). In this regard, limited attention has been given to the role of governance or institutional frameworks, with studies focusing mostly on decentralization, power distribution and the different control mechanisms associated with blockchain and new governance models (Beck et al., 2018; Pelt et al., 2021; Lumineau et al., 2021).

Polycentricity and The Tragedy of the Commons

The term "polycentricity" was first introduced by Polanyi (1951) to describe a social structure that supports individuals in collective action processes by also protecting their rights, without the need of an overarching authority (Aligica & Tarko, 2012; Ostrom, 2014). Since its introduction, the idea of polycentricity has enjoyed a wide endorsement in different domains but has shown particular prominence in governance studies and institutional theory through the work of Vincent and Elinor Ostrom (Aligica & Boetke, 2009; Aligica & Tarko, 2013). Inspired by the public administration reform in the United States in the 60s, the main idea behind the principal views on polycentricity was that there exist alternative governing set of arrangements consisting of overlapping governing regimes, which can be more efficient than the establishment of centralized systems (Bish, 1971; Ostrom, 1972; Ostrom et al., 1988). Such regimes derive from state and non-state actors that play the role of decision-making centers that interact with one another, add value and compensate for each other's weaknesses (Ostrom, 1973). Such regimes, which consist of different local governing units are based on different governing centers and coordinate through interorganizational arrangements without the need of a central authority (Ostrom & Ostrom, 1965).

Subsequently, different from a monocentric perspective where a single decision structure works as a monopoly in determining and enforcing the rules, in a polycentric system the decision structure is made up of many parties that have "limited and relatively autonomous

prerogatives to determine, enforce and alter relationships" (Ostrom,1972, 55–56). Polycentricity is considered as a system of self-regulation and interactive relations (Ostrom, 1972). In a polycentric governance system, all the actors despite being independent, are affected from one another and as such should account for the actions of all the parties involved (Stephan et al., 2019; Carlisle & Gruby, 2019). In addition, an important feature of polycentricity is the "rule of law", where the legitimacy of each actor is dependent on the constrains of social rules and collective choice mechanisms (Ostrom, 1972; Aligica & Tarko, 2012). Hence, polycentricity is considered to be based on a complex system of mutually agreed regulations, norms and incentives (Ostrom, 1972; Aligica & Tarko, 2012).

Consequently, polycentricity usually emerges in light of collective action issues (McGinnis, 2011) and has been commonly associated with the "tragedy of the commons" and its role in combating problems that stem from conflicting interests leading to an absence of joint action and lack of norms regulating common pool resources (Ostrom, 2008; Ostrom, 2000; Frischman et al., 2019). The tragedy of the commons is a concept stemming from Garrett Hardin's influential paper in which he details the inevitable exploitation of common resources until their collapse, whenever individuals enjoy unlimited access and act in their own interest unfettered by any control (Hardin, 1968). Whilst acknowledging this dilemma, Ostrom offered an alternative view explaining how common property resources could be managed through shared decision-making arrangements such as polycentricity, as a way of sustainably and cooperatively make use of the commons (Ostrom, 2000; Ostrom, 2008). Therefore, whereas Hardin's assumption did not account for the possibility of individuals to communicate and cooperate in a joint governance system, polycentric governance can offer the opportunity to effectively address the social challenge associated with the common pool resource management (Ostrom, 2007; Ostrom, 2000; Aligica & Tarko, 2012).

Lastly, the uniqueness of polycentric governance stands in the fact that its structure can be adopted beyond the initial framework to explain the complex nature of multiple decision making, the evolutionary competition between contrary ideas and the coexistence of different autonomous centers (Aligica & Tarko, 2012). This adaptable nature of polycentricity led Goertz (2007) to develop an important framework for analyzing polycentricity in different settings based on three main pillars consisting of the existence of a multiplicity of stakeholders, an overarching system of rules and norms and the presence of leadership and coordination. This has offered through the years the analytical opportunity to study polycentric governance in different social systems, which have revealed the multifaceted side of polycentricity given its potential in increasing efficiency and efficacy in terms of governance and collaboration

(Dorsch & Flaschland, 2017).

Theoretical Framework

Digital infrastructures consist of large-scale systems that are constantly going through various evolutionary phases and becoming more complex. Such systems are persistently changing over time and becoming more dynamic as they host new functions, technical features and additional social components matching the emerging needs and technological possibilities (Tilson et al., 2010; Hanseth & Lyytinen, 2010). As these infrastructures are integrated with more technological features, user interfaces and information, this leads to inadvertent changes in the architecture and governance of such systems (Ciborra et al., 2000; Hanseth & Ciborra, 2007). Different streams of research in Information Systems (IS) have categorized such changes pertaining to the architecture and governance structures as "tensions" in an effort to provide a contextual lens for looking at the evolutionary nature of infrastructures (Tilson et al., 2010; Tiwana et al., 2010; Wareham et al., 2014). According to different studies, the development and evolution of infrastructures depends on the interaction, alternation and eventual balance between these tensions - referring to any opposites having a direct or indirect effect on infrastructural architecture and governance (Henfridson & Bygstad, 2013; Lyytinen et al., 2017).

For the purpose of this research, we will focus on the architecture-governance (A-G) configuration model, which looks at the evolution of infrastructures in light of tensions between stability and change (Hanseth & Modol, 2021). This framework is particularly relevant to our research for several reasons: First and foremost, it looks at how architecture and governance interact and shape the evolution of digital infrastructures, which coincides with the objective of this research to look at blockchain architecture as a decentralized ledger and polycentricity as a governance model. Secondly, whilst different research streams in IS only recount on the intrinsic A-G relationship (Hanseth & Lyytinen, 2010; Henfridsson & Bygstad, 2013; Tiwana, 2013; Wareham et al., 2014), Hanseth and Modol (2021) go one step further and ground this relationship in light of stability and change, which are typical processes to be expected in case of any digital transformation similarly to our example. Finally, the Hanseth and Modol (2021) configuration model draws upon the concepts of assemblage theory (DeLanda, 2019) referring to an array of social and material elements that interact with each other, such as people, organizations, and interpersonal networks – that also coincide with the different constituents

encountered in our case study.

According to the A-G configuration model, architecture refers to the component's functions leading to the utilitarian aspects of a system, whilst governance describes the structures regulating the decision making process (Hanseth & Modol, 2021). According to this model, the interaction between architecture and governance can be described in terms of the intrinsic relations between different roles and processes, which we will evaluate through our case study. Subsequently, the A-G configuration model defines how the evolutionary nature of a digital infrastructure can be detailed by looking at the tensions emerging from the level of balance between modularization and integration of the technological aspects, and the autonomy and control being asserted on the system (Hanseth & Modol, 2021). Furthermore, the findings stemming from the construct of the A-G configuration model, demonstrate how there is a visible interdependency between the different actors and the technological system, leading to a mutual influence between architectural changes and decision rights. Lastly, strong coordination is described as a distinct feature leading to the A-G configuration, which if appropriately established appeared to offer continuous opportunity for the infrastructure to expand to additional users and services (Hanseth & Modol, 2021).

Consequently, in this study, we will apply the A-G configuration model by looking at blockchain's architecture as a decentralized ledger and polycentricity as the governance of the given infrastructure. In this regard, Table 1. provides a summary of the key concepts that will be associated and later evaluated through the case study.

Key Concepts	Descriptions	Main References
Blockchain Architecture	Serves as the foundation of the blockchain technology and consists of a decentralized ledger that maintains and updates all transactions recorded on the network through predefined protocols.	Nofer et al., (2017); Hawlitschek et al., (2018); Syet et al., (2019)
Polycentric Governance	Different centers of decision making consisting of limited and autonomous governing units that self-regulate and coordinate through mutual interorganizational arrangements without the need of a central authority.	Ostrom & Ostrom (1965); Ostrom (1972); Aligica & Tarko (2012)
Tragedy of the Commons	The exploitation of common resources until their collapse, whenever individuals enjoy unlimited access and act in their own interest unfettered by any control.	Hardin (1968)

Collective Action Problem	Issues stemming from conflicting interests leading to an absence of joint action and lack of norms regulating common pool resources.	Ostrom (2008); McGinnis (2011); Frischman et al., (2019)
Architecture-Governance (A-G) Configuration Model		
Architecture of Infrastructures	Refers to the component's functions leading to the utilitarian aspects of an infrastructural system.	Hanseth & Modol (2021)
Governance of Infrastructures	Describes the structures regulating the decision making process in an infrastructure.	Hanseth & Modol (2021)

Table 1. *Description of the Key Concepts*

Background of the Organization

Taurus

Taurus is the fictional name of a well-established financial institution pertaining to an intergovernmental organization. Among different functions it includes offering various contributions schemes to employees of various organizations operating internationally, which can be made use of following their retirement. Individuals who cease to work and retire permanently can make use of these schemes while residing in countries and territories all around the world. Prior to adopting a blockchain based solution, the institution depended solely on a long and manual intensive procedure for the individuals to adhere to their rightful funds. The procedure consisted in each person having to fill in a paper-based form sent by Taurus that would verify based on a series of requirements the right of a certain remuneration. This procedure would be repeated on a yearly basis and would rely on having to mail the form by Taurus to more than one hundred thousand individuals and for the form to be mailed back to the organization before receiving the compensation. A failure to return the form would eventually discontinue the expected allowance for that year.

This form of operation had been running for decades, despite the perpetual issues that had been evidenced. The first and most persevering problem related to how much the procedure relied on postal services, despite the occurrence of delays and errors in delivery due the involvement of more than 100 postal services worldwide. This had proven to be a continuous

source of anxiety for the clients who always felt uncertain whether they would receive the form on time and whether subsequently, it would be returned to the institution without facing any delays. This issue became even more evident during the start of the Covid pandemic where due to related disruptions, the mailing services worldwide were affected by extreme delays or strict lock downs that would make delivery very challenging in certain areas. Another important issue with regard to the paper-based process related to the fact that it was very labor intensive, and each form had to be sent and then verified individually. If the service would continue to rely on manual processes, it would become harder to be carried out by the small group of staff in Taurus that had been assigned to this role, given that the number of registered clients continued to increase exponentially.

Whilst the need to embrace digitalization had become imminent, similar to the Garret Hardin (1968) epitome article illustrating the tragedy of the common, the issue with embarking into a digital transformation journey would need to address how much each client would be entitled without misusing the financial resources. Such a problem would cause recursive issues to the whole organization in terms of distribution, unless a technology-based equivalent solution to the paper based process would be found to replace the later. In addition, an important element to consider in finding the right technology would be the need to provide evidence of every transaction which could be then verifiable periodically by the audit, which plays an essential role in any financial institution. In the case of Taurus, audit was of particular importance also due to the nature and structure of the organization. Being part of a multinational governmental organization and as a component of a chain of different organizations to which it serves and exchanges data with, transparency and authentication of transactions are fundamental. Finally, apart from the institutional framework of Taurus, the organizational culture being very traditional and built on a specific set of long standing norms and rules, was very hesitant to any change unless a potential digital transformation would be able to address all the organizational requirements.

Blockchain implementation

Considering the evidenced complications with the old process and having a more digital friendly vision in mind, in 2020 Taurus launched a blockchain based app that would offer the opportunity to make a series of verifications that otherwise could only be made through the compilation of the paper-based form. Using the new digital solution as depicted in Figure 1., Taurus would be able for each client opting for this alternative to show through a series of steps their proof of their existence, identity and location via an app that could easily be downloaded

on any mobile phone. The project was seen as an opportunity to digitally transform a decades long process that had proved to need a more efficient solution, whilst also addressing both the internal concerns and the issues voiced by the clients. The rationale behind the implementation of blockchain was primarily due to the compulsory obligations such as the auditing requirements. For Taurus, blockchain was the appropriate technology able to offer full transparency and security to every performed transaction within the app. The cryptographic mechanisms behind the technology would prevent the altering and manipulation of data and a digital record of every transaction would be able to be registered on the servers of multiple stakeholders or parties of interest. In addition, blockchain was considered to be the suitable technology as it offered the opportunity to also step up processes in terms of efficiency with regard to time and automation.

Ultimately, Taurus adopted a permissioned blockchain that would work as a database where transactions would be stored in the form of encrypted blocks. The transactions recorded would be unable to be transferred or distributed outside the servers of the group companies, which would also act as host for the nodes. The transactions registered on blockchain would pertain to the verification of identity, existence and location that would be made through a series of steps on the app. Any private data would only be stored on the user's device and accessed by the user only. It would not be transmitted in any way to any of the servers of the institution. The only data recorded on the blockchain in form of transactions would regard public data such as registration, fulfillment of identification steps and approval of request for a certain remuneration. Such data would be recorded, and a full trail of such transactions would be available to audit. Eventually, the blockchain based solution is now considered one of the biggest successes to date for Taurus in terms of digital transformation, and the number of clients opting for the new blockchain-based app verification method continues to increase every year. Since its introduction, reports have detailed how the new digitalized solution supported by blockchain has proven to enhance integrity and efficiency of service delivery, whilst expected to also have a direct effect on cost savings and process time in the long run.

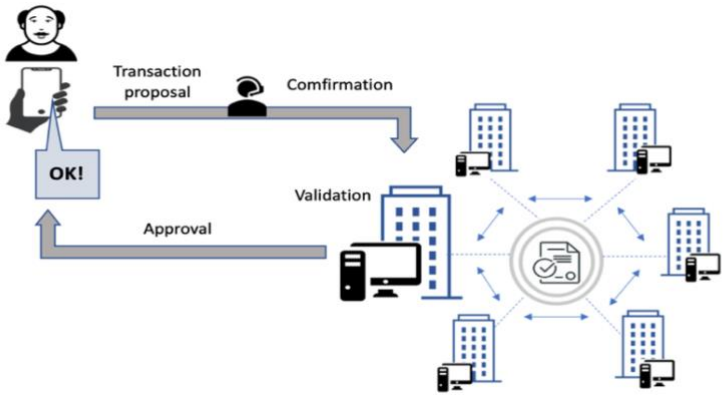

Figure 1. *Blockchain-based solution implemented at Taurus*

Nevertheless, the nature of the organization required the needs of all of the stakeholders aligned with the benefits obtained from the implementation of blockchain, which proved to be a long process of finding the right balance. Apart from radically changing the service provided to clients, the process proved to be an internal challenge of its own. The implementation of blockchain lead the introduction of a decentralized data governance system that in turn required a series of adaptations within the organization. Such changes emerged in the form of polycentricity that eventually proved to be an added value for the entire organization. As part of an intergovernmental organization, top-down approach would be expected to be imprinted with the introduction of an app, but instead through a transparent blockchain system embedded within the app, the many centers of authority could verify the transactions without the need of any centralized data governance.

Methodology

This research focuses on a single case study and the recent implementation of the blockchain technology in Taurus as a means of transforming a manual intensive labor into a digital based process that would also facilitate the services to its clients worldwide. Taurus was considered to be the ideal case relevant to the topic under review for several reasons: 1) The organization undermined the implementation of blockchain for digitally transforming services in a large scale and the initiative did not consist of a trial aiming at testing the potential of the technology alone; 2) the organizational structure and nature of the institution led to the emergence of a polycentric governance system; 3) the size of the organization that consisted

of a big financial institution with almost 300 staff members servicing over 80, 000 clients pertaining to different organizations worldwide making it a solid example 4) Taurus had already undergone previous attempts in digitalizing parts of the organization but with little success; 5) it was eventually a blockchain success story which continues to operate fully and has led to blockchain being considered to be implemented to other services as well.

Data Collection

For the purpose of this research, primary and secondary data were collected as summarized in Figure 2. Our primary data consisted of semi structured interviews taking place between September 2021 and March 2022 with representatives from different areas of the institution who were leading personas during the whole implementation operations. This allowed for all of the key functions in this project to be interviewed, including the Chief of Information Officer, Chief of Communications, Head of Client Services, Head of Risk Office in order to have a holistic view of the whole process in Taurus. The aim of the first set of interviews was to understand better the background of the project and to have direct insight into the nature of the organization under review regarding its structure, hierarchy, past attempts into digitalization and main organizational intricacies in relation to technology adoption. This was particularly useful in understanding the organizational design and culture. The second set of interviews were dedicated solely to the blockchain implementation process trying to understand the context behind such initiative, the step-by-step process until the final deployment, the main challenges, success factors and eventual outcomes since going live.

Purposive sampling was used to identify the informants and the interviews were cross-functional involving all the main individuals of each of the main departments involved in the blockchain implementation process. This was essential in this study given that the organization is based on various stakeholders and interrelated departments. Prior to each interview, an interview and data collection protocol were provided to all participants and the interviews were based on semi structured questions, which are considered particularly effective in amply delving into participants' thoughts and feelings (Fylan, 2005).

Secondary data was important in comprehending further the background story of the organization, the reasons behind the need to undergo such a digital transformation and the step-by-step development of the new technology as evidenced in official records. Secondary sources (e.g., press releases, presentation videos, audit reports) were particularly helpful in complementing the data resulting from the set of interviews in order to understand the context of the transformation within Taurus. Such materials were also useful in aiding triangulation

through multiple data sources to ensure the validity and credibility of the findings stemming from the primary data.

Type of data	Source of Data	Quantity
Semi structured interviews and online group interactions	Role within the Organization: • Chief Information Officer • Risk Officer • Chief of Client Services • Chief of Operations Support Section • Special assistant to the CEO and Head of Public Communication • Chief of Entitlement • Chief of Legal Office	Over 18 hours' worth of transcription material and notes
Archival documents	Type of Documents: • Project presentations • Video Releases • Reports (expert report, audit report)	Consisting of in over 3 hours of view duration and a total of 100,000 words long

Figure 2. *Dataset Overview*

Data Analysis and Coding

The data analysis and coding were performed through NVivo, which allowed for the organization and evaluation of all the data. This is a common tool in qualitative studies through which data analysis can be easily organized and structured (Hilal & Alabri, 2013). In producing the coding, the thematic analysis approach was implemented as a method of identifying analyzing and presenting any repeated patterns emerging from the data collected (Ryan & Bernard, 2003; Braun & Clarke, 2006). This method is particularly useful for interpreting and creating subsets of meanings from the data by facilitating the generation of relationships between various concepts (Alhojailan, 2012; Terry et al., 2017). Such a methodology is also considered suitable in qualitative research for conducting coherent analysis when dealing with information stemming from different types of unstructured data (Bell et al., 2022). The data analysis consisted into three main steps. The first step involved generating a set of initial coding based on analysis of the primary and secondary resources by capturing the main elements of interest with regard to our research question. During this step

we highlighted the relevant concepts by coding each transcript and report separately before comparing notes and modifying the final list of 39 initial empirical themes. During the second step, links and patterns emerging from the initial coding were created which led to the construct of a set of conceptual categories. In this step, we examined the codes in an effort to group them together into broader categories. Eventually 13 conceptual categories were created through the organization of the initial empirical themes. In the third step, based on insights from the literature the conceptual categories were grouped into aggregate categories. As summarized in Figure 3., the analysis eventually resulted into the emergence of 6 main themes, which we later attributed either to the governance or architectural configuration respectively based on the issue matter that they covered.

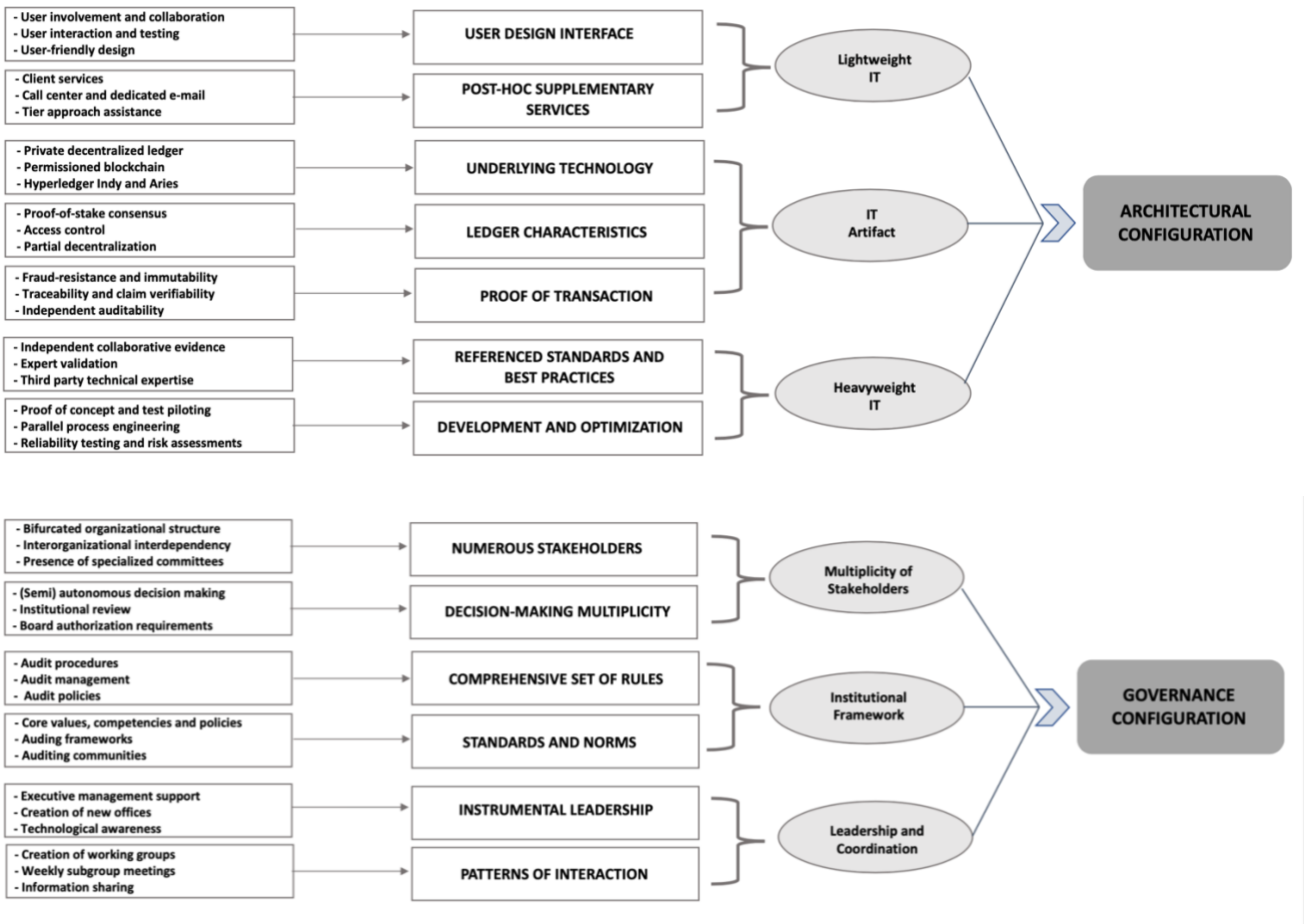

Figure 3. *Data Analysis Results*

Main Findings

Based on the analysis of the primary and secondary data which were coded, a holistic model consisting of six main dimensions related to either architectural or governance configuration emerged. The governance configuration relates to the acknowledgement of the internal dynamics inside Taurus as they were prior to the implementation of blockchain and the additional processes that followed after the introduction of blockchain. The architecture configuration on the other hand, explores the implementation of blockchain, its main characteristics and how it was established. This section will be dedicated to exploring into details the main findings pertaining to these dimensions and their respective subthemes. Subsequently, based on the findings, a dedicated discussion section will follow, which will include the construction of the theoretical model linking the main concepts.

Governance Configuration

Multiplicity of Decision Makers

Taurus is a particular organization as it is made up of various decision making centers given how it is part of intergovernmental organization. Such centers despite being interconnected with one another, present a considerable degree of autonomy. In the case of Taurus, they should be understood in a broader term, which includes people, groups, or organizations - that for the purpose of this study are affected by the change of processes and the introduction of blockchain. All of these different entities can be heterogeneous with regard to choices and decisions pertaining to the organization and form a network of complex governing system. What emerged was the fact that while the new technology would need to replace the paper based process, it would also need to ensure that it would be able to accommodate to the multiplicity of decision makers.

Diversity of stakeholders refers to the variety of individuals, groups or organizations that 1) have an inherent interest in the activities of Taurus, and 2) are affected by the outcome of the digitalization process that would substitute the paper based operations. While there are some joint administrative activities between the various stakeholders, it was noted that Taurus has in fact a *bifurcated governance structure* consisting of different independent branches. As evidenced by various internal reports, such a structure requires continuous coordination and information sharing to maintain a solid level of optimization. In addition, the institution itself is part of an intergovernmental organization, which has various other organizations under its

umbrella, causing Taurus to have an *interorganizational interdependency* with both other subsidiary organizations and the parent organization in terms of decision making. What was evidenced from the interviews, nevertheless, was the fact that these decision makers have in common their willingness to cooperate with regard to blockchain implementation. Such cooperation is to be maintained through the establishment of trust and transparency and going digital would need to ensure both aspects. In this regard the *presence of special committees* such as audit would ensure the conformity to rules and aid the process of trust building and transparency.

Decision-making multiplicity addresses the governing process due to the existence of diverse stakeholders. This includes the level of *autonomous decision making*, which describes how the different stakeholders overlap as decision making centers and operate under a semiautonomous degree as a result. All the different decision making centers should be understood as governing units that work independently but directly or indirectly affect one another. This is why, any decision to change processes would need to go through an *institutional review* and be agreed upon the *board authority* representative of all stakeholders. The same applied to blockchain implementation process, which did not prove easy especially due to concerns coming from advocate groups that believed that blockchain might not be the right technology. Nevertheless, following constructive persuasion from the IT department, blockchain was finally accepted as the most appropriate solution for Taurus. Such a choice would eventually prove useful also as a supporter of interoperability between decision makers without having to give up on autonomy.

Institutional Framework

Auditing for Taurus was pinpointed to be an essential element in providing assurance to all stakeholders. Auditing as a form of maintaining in check the quality of internal processes inside the institution is made periodically following routine examination of the records to make sure that everything is in compliance with law and regulatory frameworks. Whilst the paper based procedure could have been simply replaced by the app, embedded with the biometrics and geolocation function alone without the need of blockchain, the latter was important due to the significant role that audit plays in Taurus and for its stakeholders. In this regard, every transaction on blockchain had to be compliant of the comprehensive set of rules, standards and norms of the organization and reviewed through auditing.

Comprehensive set of rules addresses the set of statuary regulations pertaining to the

organization in terms of auditing. This makes reference to the *audit procedures, audit management and audit policies,* which were strictly considered in every step prior and during the development of the blockchain based solution. These set of rules which had to be in accordance with the organizational requirements, underlined the importance of the following: transparency, security, verifiability. Therefore, the implementation of blockchain had to secure that each of the recorded transactions on the app was in accordance with the organization's auditing policies and could be audited periodically based on the specific set of rules and procedures predisposed by latter.

Standards and norms make reference to the level of quality to be attained in terms of auditing. Such standards and norms would need to fit *auditing frameworks, auditing communities* and *auditors*. In this regard, interviewees also underlined the fact that prior to the blockchain implementation, auditing reports had referenced auditors' concerns with regard to the manual signature procedure and whether such a procedure could be considered safe and reliable in terms of client identification. By digitally transforming the process, Taurus had the opportunity to address this point and make sure that the new technology would minimize any concern in this respect. The implementation of blockchain based app where identification would be made through biometrics and every transaction would be recorded on the blockchain network would therefore address any previous concerns, whilst also offering the opportunity for faster and more efficient auditing.

Leadership and Coordination

Taurus had undergone various attempts in the past to digitally transforms different processes inside the organization with limited success. This had caused the organization to become exceptionally cautious when considering undertaking major changes in terms of digitalization. This is why most of the processes continued to be done manually in an attempt to avoid any major form of digital transformation. When asked what set apart the implementation of the blockchain based app from previous projects, all interviewees underlined the importance of leadership and coordination as instrumental in embracing the idea and in its eventual success.

Instrumental Leadership refers to the strategical executive contribution to the implementation of the blockchain. In this regard a recent change of CEO within the financial institution who showed very early an exceptional *executive support* in moving forward with the project proved to be very important in starting a new more digitally friendly era within the

organization. This had been a lacking feature in the past, where the conservative nature of Taurus had prevailed in some of the previous attempt to digitally transform part of the internal practices. The success of the blockchain implementation was also accompanied with changes internally. Within the organization, *new offices* such as the Business Transformation Office were created to support further the project and potential future endeavors to digitalize. Having experienced first-hand the benefits of blockchain, the project led to Taurus becoming more *technologically aware* and open to new opportunities. This was also supported by the fact that the initiative was accorded a prestigious award in terms of innovation. Eventually, the technological awareness was subsequently extended to other institutions under the main intergovernmental organization, which have been expressing their willingness to adopt blockchain in their systems as well.

Patterns of Interaction relates to the internal dynamics in terms of coordination. It was evident since the beginning of the project that the decades old process could only be changed if everyone within the organization would be aligned and on board with the initiative. As a result, *working groups* were created to discuss the initiative. The introduction of blockchain and the lack of proper understanding of the technology by everyone, made the need of such working groups even more essential in disseminating information about every step of the process. *Weekly subgroup meetings* were also established in which all departments within the organization could voice their concerns, doubts or issues which were to be addressed later by the IT team. Lastly, *information sharing* with regard to every step during the implementation process was pinpointed to have also been a success factor in accepting blockchain and making sure it would align with the needs and concerns of every stakeholder.

Architectural Configuration

Lightweight IT

In order for whole process to be digitalized for clients in terms of identification, application and validation of their requests, it was decided that everything would be made through an app. Through this app, clients would be able through a series of steps to identify themselves via facial recognition that would replace the manual signature requested prior in paper format. Apart from biometrical features the app would also be able to pinpoint the geolocation of the clients in order to set the correct currency to their requested remunerations - again without the need to fill any additional paper forms. Whilst blockchain would be decided to be the appropriate technology able of registering all transactions pertaining to these activities

occurring on the app, the app itself had to also be user friendly. In this regard, users (clients) were asked to collaborate by reviewing and providing feedback on the app and the user journey.

User Design Interface refers to all the main steps taken into creating the app with the help of the users prior to officially launching it. Through continuous *user involvement and collaboration* Taurus was able to make sure the app would run effectively and would not be overly complicated considering that most of the users correspond to an older generation. Various users residing all over the world were able to *interact and test* the app and its functions before the official launch, which led to the construction of a *friendly-user design* application that could be downloaded on every smartphone.

Post-hoc supplementary services include the set of processes and interactions of Taurus with the users after the launch of the app in case of further concerns or possible issues. In this regard a *client service* support was established to help through a *call center and dedicated e-mail*. Everything would be processed through these two channels of communication through a *tier approach assistance*, which as described by the interviewees consisted of assigning the questions/issues based on content and level of complication to different departments within the organization.

IT Artifact

IT Artifact refers to the development of the architectural and infrastructural bundle of blockchain to be implemented. In this particular case of digital transformation, blockchain was expected to play the most important role and it would need to address not only the organizational needs of Taurus but would also need to adhere to its particular values, norms and structures. Blockchain was first introduced as a promising alternative by the Head of the Information Technology. Nevertheless, the interviews revealed that blockchain technology was not met with the same level of enthusiasm from everyone within the organization, potentially because of the novelty of blockchain and lack of concrete understanding of how it functioned. It was met with skepticism also due to fact that it was perceived to be a costly and energy consuming technology in light of some press articles concerning public blockchains. Therefore, it was essential that the type of blockchain and its affiliated properties met the organizational requirements. Eventually, following the customized and purpose-built blockchain in addition to an extensive information campaign aiming at demystifying blockchain led to all concerns being promptly addressed.

Underlying technology refers to the main blockchain architectural characteristics that were agreed upon to be implemented in the case of Taurus. First of all, it was agreed that

blockchain would provide the infrastructure to build a *private decentralized ledger* where all the transactions recorded on the network would be accessible only by the appointed organizational bodies. This would require the establishment of a *permissioned blockchain*. Such a blockchain would not be publicly accessible and would consist of a solid access control layer. Such kind of a blockchain was ideal given the organizational needs and purposes where various degrees of centralization were still required. *Hyperledger Indy and Aries* were eventually picked as open-source projects to design and develop the permissioned blockchain and the appropriate consensus mechanisms.

Ledger characteristics describe the main features of the established blockchain for Taurus. Such characteristics included a *proof of stake consensus* referring to the consensus mechanism for processing transactions, which provided both efficiency and low energy consumption. *Access control* would be established, and the nodes would be hosted by a computer service provider belonging to the parent organization. This was essential to make sure that the transactions recorded would remain in the computing environment of the organization and would benefit from the same privacy and security privileges as the main parent organization. All these features would lead to an eventual *decentralization* in terms of network type, consisting of distributed information sharing operated by multiple independent authorities.

Proof of Transaction detail the main profits of the blockchain architecture that Taurus would benefit from. Such profits would be interpreted by the interviewees as the key to meeting the organizational needs and norms . Due to the very nature of a permissioned blockchain and the security and access protocols in place, blockchain would make every recorded transaction *fraud resistant and immutable*. In addition, by having a full record of every transaction, it would allow for every data registered to be *traceable and claim verifiable* since everything would be anchored to the ledger. Moreover, since the new system would be inherently resistant to change, it would give the auditors to easily examine and verify transactions directly through *independent auditability*.

Heavyweight IT

Soon after having decided upon the implementation of blockchain, it became evident that building the digital infrastructure was unable to be performed entirely in home by Taurus. Outside resourcing was also needed in order to perfect the implementation and minimize the risk of failure.

Referenced Standards and Best Practices refer to the process of aligning various effective procedural processes as the basis of the evaluation of the blockchain performance. In this regard, before the start of the development of the blockchain based platform, *independent collaborative evidence* was sought as benchmark for the assessment of the blockchain implementation into the app. In addition, *expert validation* was required for most of the technical details in order to make sure that blockchain met several ISO international standards, mainly in terms of security. This was particularly important also to provide assurance in terms of cybersecurity. *Third party expertise* through means of external skillful specialists in the field of blockchain provided throughout the project comprehensive support in terms of risk assessment and process improvement.

Development and Optimization prevailed after the planning as it was the most important stage in building the whole blockchain based platform and infrastructure. This consisted with mainly three main processes. The first consisting in creating a *proof of concept*. Various feasibility demonstrations were conducted in order to showcase the successful execution of the blockchain based platform. Secondly, *parallel process engineering* was also adopted in order to run processes simultaneously. *Reliability testing and risk assessments* were also performed continuously to make sure that all operations could be executed failure free. Eventually a *test pilot* was performed before going live to evaluate the feasibility and address any final bugs.

Discussion

In the case of Taurus, the main findings emerging from the analysis describe how blockchain as a decentralized architecture and polycentricity as a governing system, intertwine with one another to form a symbiotic relationship. The implications stemming from our analysis showcase how the implementation of blockchain process and the establishment of polycentricity extend the current understanding of tensions in terms of stability and change (Hanseth & Modol, 2021). The relationship between polycentricity and blockchain emerges in terms of needs and solutions, autonomy vs control, strong coordination and interdependency between actors and processes. The main findings emerging from this study have been summarized into a theoretical model as depicted in Figure 4 by representing all the elements leading to a series of A-G outcomes resulting from their interaction.

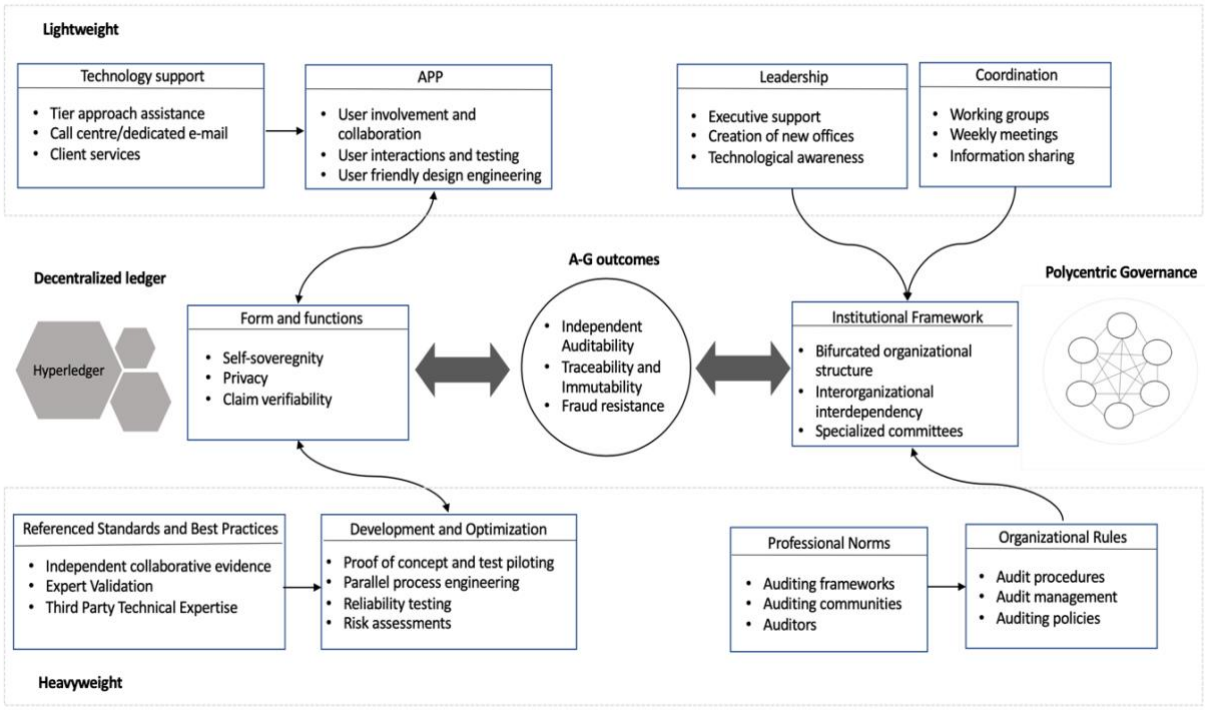

Figure 4. *Theoretical Model*

For Taurus, blockchain was considered the adequate technology as it would fit the specific organizational needs in terms of auditing and security, coinciding with research depicting blockchain as a promising solution fitting various institutional demands (Guegan, 2017; Zheng & Lee, 2020). From a practical perspective, blockchain was able to generate a successful digital transformation by reorganizing a decade old process and service delivery, which is in line with studies pointing out the role of blockchain as a novel approach to digital transformation. (Rot et al., 2020; Dokuchaev et al., 2020; Bhati et al., 2020). In addition, by offering an automated and optimized solution, the blockchain based app was able to offer an easier and faster servicing expected to also be very cost effective in the long run. This is consistent with the studies analyzed, which highlight the role of blockchain in alleviating efficiency (Hughes et al., 2019; Spahiu et al., 2022). Nevertheless, the analysis also revealed that the implementation of blockchain would require the integration of the new digital infrastructure with adequate heavyweight and lightweight IT (Ismail et al., 2019; Dhanda et al., 2019). In the case of Taurus, heavyweight IT consisted of the advanced software engineering developed by experts and the assistance of third-party expertise, while we associate lightweight IT with the socio-technical components driven by user needs and

addressed through the app and technical support (Alemdar & Ersat, 2010; Bygstad, 2017).

However, in spite of the fact that blockchain was considered the appropriate technology from early on, its implementation required attention beyond the technical standpoint. Thus, the adaption to the blockchain based solution on an organizational governance level led to the emergence of polycentricity. Taurus was not initially polycentric and the only element corresponding to polycentricity was the existence of limited autonomous structures (Ostrom, 1972). In addition, the organization diagram showed that there was too much government in place but little governance as there was a lack of proper coordination, which is typical of a centralized non polycentric system (Ostrom et al., 1961). With the introduction of blockchain, every transaction would be able to be recorded and secured through cryptography on multiple servers pertaining to all parties of interest (Nofer et al., 2017; Syet et al., 2019; Zacharadies et al., 2019). This provided a new outlook on interorganizational relations, which coincides with literature on blockchain implications (Tapscott & Tapsocott, 2017; Angelis & Da Silva, 2019). In addition, from a polycentric perspective the implementation of blockchain resulted in new forms of interactive relations (Ostrom, 1972) through the development of newfound coordination and leadership mechanism. In this regard, Aligica and Tarko (2013) underline that a polycentric model is characterized by the willingness of stakeholders to cooperate, which in the case of Taurus emerged gradually to create a network of interaction through blockchain. Moreover, our analysis extends previous research showcasing the importance of the "rule of law" in polycentric governance models (Ostrom, 1972; Aligica & Tarko, 2012; Aligica, 2015). In the case of Taurus, the implementation of a blockchain based app was accompanied by a specific set of rules and norms with regard to audit that would serve as essential operational boundaries and aide in addressing any collective action problems that might arise (Ostrom, 2008; McGinnis, 2011; Frischman et al., 2019). In turn, all of these emergences resulted in a newfound balance between control and retained autonomy of different processes, which tackles Hardin's concern with regard to the "tragedy of the commons" (Hardin, 1968), in addition to coinciding with recent views on the leading factors affecting architecture and governance in the evolution of large-scale infrastructures (Hanseth & Modol, 2021).

Overall, the emergence of all the polycentric properties during the process of digital transformation facilitated the blockchain implementation leading the to the technology being subsequently accepted and widely embraced as a technology. On the other hand, the establishment of blockchain offered the opportunity to aide further in cooperatively making use of the commons and address any issues related to common pool resource management (Ostrom, 1973; Ostrom, 1994; Ostrom, 2007; Aligica & Tarko, 2012). Our analysis

complements the current understand of digital infrastructures and how they become complex as they are fitted with new technological components (Tilson et al., 2010; Hanseth & Lyytinen, 2010). In addition, the findings emerging from the investigation of blockchain implementation in Taurus, revealed how the complexity of digital infrastructures are consequently accompanied with various alternations to architecture and governance (Ciborra et al., 2020; Hanseth & Ciborra, 2007; Henfridson & Bygstad, 2013). Lastly, similar to Hanseth and Modol (2021), our analysis highlighted the intrinsic relationship between different roles and processes, the interdependence between actors and strong coordination as important elements in the evolutionary dynamics of infrastructures in terms of architecture and governance.

Main Implications

Blockchain implementation should be understood as a complex and dynamic process. For the purpose of this research, we proposed an A-G approach to analyze blockchain implementation in relation to polycentricity, in order to order a new perspective on studying blockchain and governance structures together. In terms of the evolution of digital infrastructures, the findings emerging from this research support existing literature on the intrinsic relationship between architecture and governance (Ciborra et al., 2000; Hanseth and Ciborra, 2007; Henfridsson and Bygstad 2013). In addition, our research confirms how the architecture and governance configuration lead to the emergence of tensions that need to be accommodated (Tilson et al., 2010; Tiwana et al., 2010; Wareham et al., 2014). In the case of Taurus, such tensions emerged mostly in terms of autonomy vs control and stability vs change as the infrastructure was developed in order to accommodate for the implementation of blockchain.

Moreover, this study offers important implications with regard to polycentricity in view of emerging technologies such as blockchain. In this regard, the study shows how blockchain can have a positive impact on polycentricity by enforcing some of the most characterizing features of this governing system. In this regard, the implementation of blockchain was able to aide in mutually enforcing regulation between decision making centers (Ostrom, 1972; Aligica & Tarko, 2012) and address issues related to common resource management (Ostrom, 1973; Ostrom 2008). Conversely, the emergence of polycentricity was shown to have a facilitating role in the implementation of blockchain. This showcases how governing structures can play a key factor in leading to a positive implementation outcome and therefore, more attention should

be given to the socio-technical aspects of blockchain implementation processes.

From a practical perspective this study concurs on the role of blockchain in offering a series of benefits in terms of digital transformation (Rot et al., 2020; Dokuchaev, 2020), efficiency gains (Hughes et al., 2019; Spahiu et al., 2020) and trust building due to its characterizing properties (Hawlitschek et al., 2018; Angelis & Da Silva, 2019). In addition, by introducing the case of a successful blockchain implementation we detailed the important elements that lead to a positive outcome of this implementation. In this regard, we expect this study to offer new insights to innovation managers on how to better leverage blockchain for digital transformation based on a series of considerations in terms of architectural configuration and governance arrangements that would aid the process of implementation. Lastly, through this study we address the call for the need of more studies identifying the main elements leading to the successful implementation of blockchain from a case-based perspective (Rossi et al., 2019; Treiblmaier, 2020).

Limitations and Future Research

This research is based on a single case study which can result in some limitations. Considering that the case under review employed the use of blockchain as part of a specific set of requirements and was based on a financial institution belonging to an intergovernmental organization thus having a particular nature and scope may result in limitations with regard to generalization of the findings. Taking this into consideration, this research aimed at looking past the mere organizational needs for pursuing blockchain, but rather at the implementation process of the new blockchain based app. In addition, data was collected between a specific timeframe and the new blockchain based solution is still being improved based on the periodical feedback received internally within the organization and externally from users. In this regard, following the collection of primary and secondary sources, authors have continued to be in touch with the organization in case of any substantial issues emerging worthy of further consideration.

Furthermore, limitations of a case study research could also relate to issues of construct and internal validity. To address any validity limitation secondary data was used in addition to primary data sources for the purpose of triangulation of the findings. In addition, the interviewees were specifically selected to be directly involved in the project and correspond to different departments in order to create a better holistic understanding. Nevertheless, future

research can focus on complementing our findings by examining other similar case studies through a same contextual and theoretical analysis in order to verify or expand our findings. Subsequently, this research can serve as a first step for upcoming studies to analyze blockchain and digital transformation from the point of view of different actors, including clients as well since for our research the service dominant logic approach was analyzed through the eyes of Taurus alone.

Conclusion

Blockchain has become a frontline technology for enhancing processes and services into becoming more transparent, efficient, reliable, and secure. Despite the potential implications associated to the technology and exponential increase in terms of implementations, success stories especially for large organization to draw implications upon remain limited. In this paper we propose to look at the successful case of a blockchain implementation in a financial institution of an intergovernmental organization through the lens of polycentricity. In doing so we adopt the Architecture - Governance configuration model by Hanseth and Modol (2021) to describe the intrinsic relationship of the blockchain as decentralized based architecture and polycentric governance. This study contributes to the body of research on blockchain by underlining the role of governing structures as an important element aiding implementation. In addition, it aims at contributing to the discourse on the evolution of digital infrastructures in light of new technologies and polycentric governing structures.

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Final Remarks

Blockchain has been considered a disruptive technology whose properties and characteristics have provided, at an unprecedented rate, an innovative outlook to registering exchanges, the creation of trustless systems and network management. Nevertheless, despite the quick emergence, there is a lot that remains to be analyzed and discovered about the technology. In this regard, this thesis aimed to extend current research towards some of the most understudied areas in an effort to provide a better understanding of the blockchain technology from a socio-technical perspective. The body of work encompassed in this thesis consist of three papers, each addressing a distinct research question as follows:

- *What are the observed dimensions of blockchain initiatives in the public domain?*
- *How can blockchain be integrated into PA infrastructures?*
- *How can a blockchain based architecture combine successfully with a polycentric governance system?*

In order to address such questions, this thesis was grounded mainly on extensive literature review and primary data, which for the purpose of this study consisted predominantly of interviews conducted directly with professionals involved in blockchain implementation projects and initiatives. Subsequently, the overall goal was to understand why and how a blockchain-based solution challenges existing theories of IT-based organizational change. Moreover, it increases the understanding of outcomes, tensions and mechanisms of successful blockchain implementation. In doing so this study provides a taxonomy of blockchain outcomes; extends the concept of blockchain-based Information Infrastructures and tensions; and investigates the intrinsic relationship between architecture and governance in the evolution of digital infrastructures occur in view of blockchain and polycentricity.

The three chapters and consequently the three questions were based on findings pertaining to the public domain. Nevertheless, despite such focus, given the nature of the results, inferences can be made on the potential of most of the findings to be relevant for both the private and public domains. In the first study, apart from specific use cases identified and public value associated exclusively to the public sector such as welfare distribution and democracy,

the rest of the identified categories could be easily applicable in the private sector. Similarly, in the second study, the emerging tensions relate to operational issues, internal factors and problematics originating from competing needs and priorities between different stakeholders – which could be expected to be equally significant to organizations operating in both public and private domain. Lastly, given how the third study looks at polycentricity - a highly recognized theme in governmental studies - the implications stemming from this research could be expected to be equally useful in both public and private organizations operating through multilevel governance or looking to address any collective action problems.

Future work could be directed towards extending the findings and implications emerging from this thesis by evaluating how results compare and contrast in different settings. Similarly, this research could also be leveraged as a first step intro addressing the emergence of blockchain through similar theoretical lenses in an array of contexts and specific industries in an effort to provide a more holistic view on the technology. Furthermore, new research could explore how the emerging tensions regarding blockchain can be addressed from a practical perspective, and in addition, look at blockchain based applications in light of various other governing models and systems beyond polycentricity.