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DISTRIBUTED LEDGER TECHNOLOGY (DLT) AND IT GOVERNANCE: THE BASIS FOR DEFI, CBDC AND TOKENIZED ASSETS.

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ABSTRACT

Blockchain is a Distributed Ledger Technology (DLT) which supports cryptocurrencies, Decentralized finance (DeFi) is a blockchain-based financial infrastructure, the term generally refers to an open, permissionless, and highly interoperable protocol stack built on public smart contract platforms, such as the Ethereum blockchain. DeFi does not rely on intermediaries and centralized institutions. Instead, it is based on open protocols and decentralized applications (Dapps). Considering that there are many digital coins, stablecoins and recently the advent of central bank digital currencies (CBDCs by Central Banks) and tokenized assets it is important to observe that these protocols may interact among themselves. These IT protocols interactions may be complex and there should be effective IT governance frameworks to guide points like interoperability and interconvertibility of digital assets based on DLTs protocols. IT governance framework based on these technologies is still a challenge in the literature. Considering these points, this paper explores the literature through a Systematic Literature Review methodology in order to find the state of the art about this theme. Results show that Literature focus DLT governance as a whole, including information technology (IT) aspects. However, there is a lack in the literature about IT governance for interoperability and interconvertibility among complex DLT protocols interactions. Discussions, future research, limiting factors and conclusions are fully stated.

Keywords: Distributed Ledger Technology (DLT), IT Governance, Central Bank Digital Currency (CBDC), Tokenization, Decentralized Finance (DeFi).

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INTRODUCTION

Blockchain is a technology that allows a growing list of data structures (blocks) connected and secured by cryptography. In a Blockchain, the distribution of information is decentralized (Haber and Stornetta, 1990). According to Tasca (2015), cryptocurrencies can be defined as: *"Money expressed as a string of bits sent as a message in a network that verifies the authenticity of the message via different mechanisms, such as proof-of-work (PoW) or proof-of-stake (PoS)".* All transactions are traceable regarding the fact that they are recorded in a public ledger (Tasca, 2015).

According to Schär (2021) Decentralized finance (DeFi) is a blockchain-based financial infrastructure. The term refers to an open, permissionless, and highly interoperable protocol on public smart contract platforms, such as the Ethereum blockchain. DeFi does not rely on intermediaries and centralized institutions. Instead, it is based on open protocols and decentralized applications (DApps). Smart contracts can perform roles executed by intermediaries (Schär, F., 2021). Smart contracts refer to applications stored on a blockchain and executed by a set of validators. DeFi has the potential to set an open, transparent, and immutable financial infrastructure. Considering that DeFi consists of numerous highly interoperable applications (and protocols), everyone in the system can verify all transactions and data. DeFi leads to a more open and transparent financial infrastructure (Schär, F., 2021).

Stablecoins can be understood as a category of cryptocurrency that seeks to stabilize the price by connecting the value to an underlying basket of assets. Stablecoins may work as digital equivalent of stable value funds, but their design is rather complex and involves the broader crypto economy. Stablecoins may require a governing body, exchanges, wallet providers, payment system operators, smart contracts, and a Distributed Ledger Technology (DLT) or blockchain system. Stablecoins are able to be backed by USD or other cryptocurrencies (crypto collateral) (Van der Merwe, 2021).

According to the International Monetary Fund (IMF) Central Bank Digital Currency (CBDC) may be understood as a kind of legal tender in digital form, following the primary money functions (Kiff *et al*., 2020). A CBDC should allow central banks provide a universal means of payment for the digital era, safeguarding consumer privacy and preserving the private sector's primary role in retail payments and financial intermediation (BIS, 2020).

DeFi can cover a variety of activities relationships. like stablecoins, exchanges, credit, derivatives, insurance among others. DeFi operates in a decentralized environment (public, permissionless blockchains). Services are generally encoded in open-source software protocols and smart contracts. DeFi protocols seek to disintermediate finance in a new governance. The market experienced explosive growth beginning in 2020. According to tracking service Defi Pulse DeFi grew over $15 billion at the end of 2020, and over $80 billion in May 2021(Defi Pulse, 2021).

DeFi is mainly based on the application of blockchain beyond cryptocurrency what generally involves private or permissioned blockchains that are controlled by a central entity or consortium of entities that governs the information flown among participants. According to Van der Merwe (2021) The crypto economy typically consists of four, interrelated components, they are I. The distributed ledger or blockchain, II. Digital assets, III. The active participants or miners and IV. The passive participants or users. A particular blockchain is composed of blocks or groups of cryptocurrency transactions (Van der Merwe, 2021).

These new forms of governance, which are centralized in computer codes, emphasize the need for new research on organizational governance accounting for the interdependence of various levels

about blockchain-based organizations. Foreseeably, this collaboration between centralized financial institutions and decentralized blockchain organizations will also foster the emergence of hybrid governance forms across organizational boundaries (Hsieh *et al*., 2017).

Convertibility among monetary instruments and interoperability between platforms will be crucial in reducing barriers to trade and enabling competition. Digital currencies may also cause an upheaval of the international monetary system: countries that are socially or digitally integrated with their neighbors may face digital dollarization, and the prevalence of systemically important platforms could lead to the emergence of digital currency areas. The advent of digital currencies will have implications for the treatment of private money, data ownership regulation, and central bank independence. For monetary policy to influence credit provision and risk sharing. In a digital economy where most activity happen through networks with their own monetary instruments, a regime in which all money is convertible to a central bank digital currency (CBDC) would uphold the unit of account status of public money, if a CBDC worked like stablecoins (Auer & Böhme, BIS 2021).

Laurindo (2008) stated that Information Technology (IT) is a widely accepted term that includes in its meaning; equipment (such as computers, servers, network, communication technology, automation, and network devices), applications, services, human, administrative and organizational aspects (Laurindo, 2008; Porter & Millar, 1985).

Brazil has been fostering the adoption of cryptocurrencies and tokenized assets, even by its Central Bank (Bacen). Recently it was approved two projects of crypto regulations (compliance) PL 3825/2019 and PL 4401/2021 in the country. The Central Bank of Brazil seeks to establish in use the Brazilian central bank digital currency (CBDC) in the year of 2024. Considering this introduction, it is justifiable to explore and assist further the Information Technology (IT) governance based on decentralized technologies such as distributed ledgers (DLTs). Specifically. about the interaction and interconnection among different cryptocurrencies, stablecoins, central bank digital currencies (CBDCs) and tokenized assets.

In this context there will be interaction among different decentralized IT protocols based on DLTs. In The Literature there is still a gap in providing IT governance frameworks for the interconnection among decentralized IT and DLTs protocols, what does justify and encourages this study to be accomplished. Figure 1 below shows interactions among cryptocurrencies, stablecoins, CBDCs and tokenized assets. Each one has its own IT Distributed Ledger Technology (DLT) protocol.

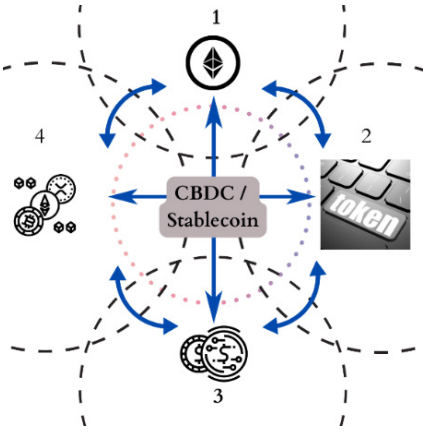


Figure 1. Complex interactions among different IT (DLTs) protocols.
Source: Authors.

Meaning:

1.Cryptocurrency "A".

2.Tokenized Assets.

3.Cryptocurrency "B".

4.Other cryptocurrencies.

In figure 1 above it is possible to realize that there are multiple interactions and intersections among cryptocurrencies, CBDCs, Stablecoins and tokenized assets. Each dashed line stands for its own distributed ledger DLT / IT protocol. The figure also shows the interaction and interconnection among different IT protocols. In this point there are some properties like interoperability and interconvertibility among assets. For these occasions there should be effective IT governance frameworks.

Considering this scope, this paper seeks to answer a main question: Identify and compile the state of the art in literature about IT governance related to Distributed Ledger Technology (DLT). Additionally, these findings may help identify governance aspects related to interoperability among different protocols. This is the main research goal of this study. To answer this, a Systematic Literature Review (SLR) is considered.

LITERATURE REVIEW AND THEORETICAL BACKGROUND

Weill & Ross (2004) define IT governance being the decision rights and accountability framework for encouraging desirable behaviors in the use of IT. IT Governance reflects corporate governance focusing on management and use of IT to achieve goals. IT governance does not work solely, it relates to other key enterprise assets and decisions. The authors also point out that enterprises design three categories of governance mechanisms, they are: 1) decision making structures; 2) Alignment Processes; and 3) Formal Communications. According to Weill & Ross (2004) IT governance is also related to IT principles, IT architecture and IT infrastructure (Weill & Ross, 2004[2]).

IT governance enables firms with effective tools Improving the allocation of IT decision rights and management of IT risks, to achieve firms' business goals (Joshi *et al*, 2018). The ultimate objective of IT governance is to create synergy between business and IT to obtain business value through IT investments (Weill & Ross, 2004). According to Joshi *et al* (2018) there are many studies indicating that a higher level of IT governance maturity is positively associated with higher IT-business alignment, IT governance performance, customer trust, and business performance (Joshi *et al*, 2018).

According to Weill *et al* (2002) IT infrastructure: *"is the base foundation of budgeted-for IT capability (both technical and human) shared throughout the business in the form of reliable services that are centrally coordinated. Infrastructure links IT-based capabilities in the enterprise to business partners, external infrastructures such as bank payment systems, and to public infrastructures such as the Internet"* (Weill *et al,* 2002).

According to Nabilou (2021) Bitcoin is the oldest and most established cryptocurrency network with the biggest market capitalization. The Bitcoin is associated to a decentralized financial market infrastructure that clears and settles transactions in its native asset without relying on the conventional

financial market infrastructures. Bitcoin needs to have robust governance arrangements; whether such arrangements are built into the protocol being on-chain, off-chain, or hybrid forms of governance. (Nabilou, 2021).

According to Nabilou (2021) the literature on internet governance has shown two opposing forces: government-centric multilateral governance model and the private-sector-led multi-stakeholder governance model (or distributed governance model). The author points out that the Bitcoin governance shares many common features with internet governance, considering that both governance models deal with governance in decentralized systems. The author states that the internet governance the closest model that could be analogized to Bitcoin governance. Nabilou (2021) calls attention to the distinction between permissioned and permissionless blockchains. Due to their decentralization, in permissionless networks no entity might be identified to have major control of the network affecting the governance (Nabilou, 2021). Permissioned blockchains are inaccessible for external parties not recognized by a system administrator (Labazova, 2019).

Ethereum is an infrastructure for implementing smart contracts (Gudgeon et al., 2020), these are contracts with predefined terms and conditions (Dong et al., 2018; Meralli, 2020; Tien et al., 2020), that are self-executing eliminating the need of a central agent (Yang et al., 2020). Smart contracts define the terms and penalties of a contract, but may also monitor, execute, and enforce the contract terms over the blockchain (Atzori, 2015; DuPont, 2017). These characteristics enable information to be shared (Notheisen et al., 2017) hence decreasing information asymmetry and transaction costs. Smart contracts can be used for a wide range of digital assets (Chen, 2018), creating tokens that can either be fungible tokens or non-fungible tokens, which are unique (Westerkamp et al., 2020).

Ethereum is also a computer platform able to run all sorts of smart contracts. All Ethereum's Decentralized Applications (Dapps) are run on the same virtual machine, use the same language and the same "primitives" relying on and validating transactions in the same blockchain (Arruñada and Garicano, 2018).

Ethereum is the principal base platform to build blockchain-based financial services, not controlled by a single entity, known as Decentralized Applications. (Frankenfield, 2018; Li et al., 2021) Ethereum has been taken into consideration by regulators once the technology may affect regulation and public policies, including monetary provision (Grassi et al, 2022). Decentralization is the elimination – or reduction – of the intermediation and centralized processes that have traditionally been involved in the provision of financial services (Financial Stability Board, 2019).

DeFi-based financial system involves more decentralization, innovation, interoperability, borderlessness, transparency (Chen and Bellavitis, 2020; Tien et al., 2020), security and integrity (Gudgeon et al., 2020). Smart contracts Allows to operate and control the ecosystem "algorithmically and - potentially – entirely without human intervention" (Harwick and Caton, 2021; Diedrich, 2016). The Smart contract governance of blockchain applications and infrastructure integrates decentralized decision-making processes and coordination mechanisms. There is distributed governance on blockchain-based platforms. Blockchain technologies are able to redesign public management structures through smart governance systems (Balcerzak *et al*, 2022). The blockchain technology is based on automated and trustless transactions (Atzori, 2015).

Swan (2015) said that the main principles of blockchain-based governance can be summarized in the following points: (*I)Centralized organizations and the problem of scale; (II) State as a Single Point of Failure (SPOF); (III) Distributed architecture and trust-by-computation: "Code is law";(IV) Power of individuals and politics by instant, atomic interactions; (V)"Putting a nation on*

the blockchain" a Starbucks-style public administration; (VI) *Borderless, globalized government services; (VII) Systems of direct democracy;* (VIII) *Futarchy: "Vote for values, but bet on belief"; (IX) A decentralized society, still based upon the State authority; (X) A new social contract, characterized by Decentralized Autonomous Societies and the final demise of the State; (XI) Franchulates; and (XII) Authority floating freely, cognitive dissonance and societal maturity* Swan (2015).

According to Liu *et al* (2022) there is a lack of systematic guidance on the governance of blockchain, the authors proposed a blockchain governance framework and called attention to the fact that existing IT and data governance frameworks can hardly be applied to blockchain, as there is not a central source of authority within blockchain. The authors proposed a blockchain governance framework by using case study methodology on five well-known blockchain platforms: Bitcoin, Ethereum, Dash, Tezos, and Hyperledger Fabric (Liu *et al*, 2022).

The authors observed that the level of decentralization nature of blockchain differentiates its governance from existing governance frameworks with the absence of a clear source of authority. The authors proposed a Blockchain governance mechanism based on six governance principles, they are: (I) Consider the level of decentralization; (2) Provide stakeholders aligning incentives to achieve Consensus; (3) Enable transparent decision process for trust; (4) Establish role-based accountability through both institutional and technical means; (5) Support ecosystem-level governance; and (6) Manage legal compliance and ethical responsibility (Liu *et al*, 2022).

Decentralized Autonomous Organizations (DAOs) are organizations where the interaction of members is mediated by a blockchain application, which is controlled by rules embedded in its source code. DAOs may autonomously hire people, provide services, gain money, own smart property, coordinate with other autonomous software and promote cooperation (De Filippi and Hassan, 2018; Wright and De Filippi, 2015). Blockchain enabled the existence of DAOs which have come as a new form of collective governance, in which players may organize themselves relying on decentralized infrastructure (El Faquir *et al*, 2020). According to Morrison et al (2021) the DAO is an exception to Weill and Ross (2005), since The DAO's corporate governance and IT governance are the same. The authors say that corporate governance (in DAOs) is completely infused with the IT function and governance, this applies even to Agency Theory (Morrison et al, 2021).

Wimmer et al (2018) define interoperability governance as a provider: *"the enabling framework, processes, managerial and steering functions such as reference architecture and support instruments for decision making".* Interoperability governance ensures that interoperability enablers and artefacts are aligned with the overall interoperability objectives at policy level. There should be alignment between strategic interoperability objectives and public services within and across policy domains (Wimmer et al, 2018).

Decentralized governance, based on Distributed Ledger Technologies (DLTs) may show lower resource transfer costs (Davidson, De Filippi & Potts, 2018) being scalable democratic decision-making supportive of greater societal complexity (Benkler 2016, Abramaowicz 2016). Decentralized Governance can be seen as a pluralistic view of governance in which a distributed group of participants stablish a coordination of actions towards commonly accepted outcomes. In decentralized governance, behaviors and incentives of distributed players may facilitate the achievement of governance objectives (Beck *et al*, 2018; Hofmann *et al*, 2017; Rhodes, 2008).

A Distributed Ledger is a decentralized record of information that is in agreement among belonging parties. (Nakamoto, 2008; Nakamoto, 2009). In the last point of this review, regarding tokens and assets tokenization, according to Sazandrishvili (2020) token is a digital asset, or a code and Tokenization is a method that converts rights to an asset into digital tokens (these can be bought, sold, or traded on blockchains). About asset tokenization, physical assets are turned into digital assets. This enables a digital asset to be subdivided and its subunits might be represented by a digital token (Sazandrishvili, 2020). Considering the references stated above, the main background to be considered in this research are shown in table 1 below.

Table 1. Main Theoretical References

Object of Research	**References**
Decisions Rights and Accountability - IT Governance	Weill & Ross (2004)
Blockchain based governance	Swan (2015) & Liu *et al* (2022)
Interoperability Governance	Wimmer *et al* (2018)
Distributed Ledger Technology - Decentralized Governance	Davidson S., De Filippi P., Potts J. (2016) & (2018); Benkler (2016); Abramaowicz (2016).

Source: Authors.

METHODOLOGY

This paper considers a Systematic Literature Review (SLR). It is important to understand the relationship between Information Technology (IT) governance and Distributed Ledger Technology (DLT). This paper seeks to answer a main question through a SLR methodological approach along with content analysis of the selected literature reviewed. Main question to be answered and paper objective: Identify and compile the state of the art in literature about IT governance related to Distributed Ledger Technology (DLT). Additionally, these findings may help identify governance aspects related to interoperability among different protocols.

This paper applies SLR approach (Tranfield, Denyer, & Smart, 2003) in combination with Kitchenham (2004) and Kitchenham *et al*. (2009). As suggested by these authors, the literature review can be subdivided into three main phases: planning the review, conducting the review, and reporting it.

I. Planning the Review

The review considers the following meanings: “Distributed Ledger Technology” AND “IT Governance”. Sources considered: Scopus and Web of Science. These sources were considered because they are among the most used sources in academic environments. They do provide most of published literature. Table 2 below details the criteria.

Table 2. Including and Excluding Criteria

Including Criteria	Excluding Criteria
• Papers covering both Distributed Ledger Technology (DLT) and Information technology (IT) Governance.	• Papers that do not cover relationship between DLTs and Information Technology or were not helpful to answer the main question.
• Academic papers.	• Papers about other fields (than finance/ digital economy).
• Papers related to the financial industry (or could have a connection, for instance the use of artificial intelligence) and with open access through USP VPN.	• Papers that were not fully (open) available (whole document) in the sources searched.

Source: Authors.

II. Conducting the review

The search was performed using the Web of Science and Scopus scientific databases using the final strings in Table 3. Drawing on the methodological frameworks of Tranfield *et al*. (2003); Kitchenham (2004) and Kitchenham *et al*. (2009). For Scopus database the terms were searched in abstracts, titles, and keywords, without any other constraints. For Web of Science database, the strings were searched in "Topics". In this phase, the following articles information were exported: title, authors, abstract, publication year, keywords, source title, document type and language.

Thus, papers exported metadata were saved on Microsoft Excel spreadsheets and the duplicated were eliminated. The available literature found was selected, inclusion and exclusion criteria were applied. The full articles selected were exported and the quality criteria were applied. Based on the full content of each selected article, the data extraction was subject of a critical analysis to seek literature answers for the main question of this paper.

Table 3. Database and Search Strings

Search ID	Scientific database	Search String
A	Web of Science	SEARCHED IN TOPICS The review considers the following meanings: ("Distributed Ledger Technology) AND ("IT Governance")
B	Scopus	SEARCHED IN TITLE, ABSTRACT AND KEYWORDS The review considers the following meanings: ("Distributed Ledger Technology") AND ("IT Governance").

Source: Authors.

III. Reporting the review

This item is written in item four of this paper, "Results".

RESULTS

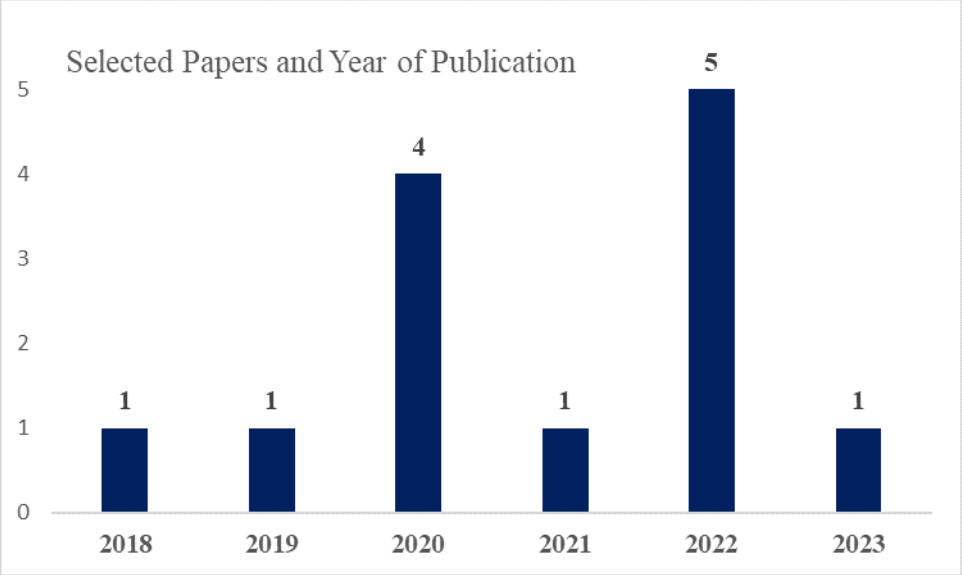
Thirteen papers were fully considered for further analysis to answer the main question of this paper. It is important to mention that all of them are relatively new publications. Graph 1 below points out the amount of the selected papers according to the respective year of publication, and Table 4

Table 4. Numbers found

Numbers Found	Web Of Science	Scopus
Total Itens found	71	130
Available (Open access)	30	38
Considered for reading[1]	07	06

Source: Authors.

[1]Reached the including criteria and excluding repeated papers. For Scopus, two papers were repeated in comparison to WoS. There were initially eight papers considered for Scopus.



Graphic 1. Number of chosen papers and respective year of publication

Source: Authors.

Table 5 below points out each paper considered in this study to answer the two proposed questions, and Table 6.

Table 5. Literature selected to answer the paper main question.

Work Title	Source	Authors	Year
Approaching Non-Disruptive Distributed Ledger Technologies via the Exchange Network Architecture	WoS	Emanuel Palm, Ulf Bodin, and Olov Schelén.	2020
DLT-based enhancement of cross-border payment efficiency – a legal and regulatory perspective	WoS	Dirk A. Zetzsche, Linn Anker-Sørensen, Maria Lucia Passador & Andreas Wehrli	2022
Investigating the Decentralized Governance of Distributed Ledger Infrastructure Implementation in Extended Enterprises	WoS	Bokolo Anthony Jnr [1]	2022
Organizational Building Blocks for Blockchain Governance: A Survey of 241 Blockchain White Papers	WoS	Petri Honkanen, Mats Nylund and Magnus Westerlund	2021

Table 5. Cont.

Work Title	Source	Authors	Year
Governance and control in distributed ledgers: Understanding the challenges facing blockchain technology in financial services	WoS	Markos Zachariadis, Garrick Hileman, Susan V. Scott	2019
Governance in the Blockchain Economy: A Framework and Research Agenda	WoS	Roman Beck, Christoph Müller-Bloch, and John Leslie King	2018
On the Convergence of Artificial Intelligence and Distributed Ledger Technology: A Scoping Review and Future Research Agenda	WoS	Konstantin D. Pandl , Scott Thiebes , Manuel Schmidt-Kraepelin , And AliSunyaev.	2020
Automating governance: Blockchain delivered governance for business networks	Scopus	David Petersen	2022
Comparative analysis of permissioned blockchain frameworks for industrial applications	Scopus	Vittorio Capocasale, Danilo Gotta, Guido Perboli	2023
Implications of blockchain distributed ledger technology for records management and information governance programs	Scupus	Patricia C. Franks	2020
Caught in the middle? Strategic information governance disruptions in the era of blockchain and distributed trust	Scopus	Victoria L. Lemieux, Chris Rowell, Marc-David L. Seidel, and Carson C. Woo	2020
Blockchain-Aided and Privacy-Preserving Data Governance in Multi-Stakeholder Applications	Scopus	Rodrigo Dutra Garcia , Gowri Sankar Ramachandran , Raja Jurdak , and Jo Ueyama	2022
Toward a collaborative governance model for distributed ledger technology adoption in organizations	Scopus	Bokolo Anthony Jnr [2]	2022

Source: Authors.

Table 6. Main findings from each selected paper.

Markos Zachariadis, Garrick Hileman, Susan V. Scott (2019)
• The authors focused some key aspects related to distributed Governance, such as: the balance of integrity and autonomy; decision-rights; control mechanisms; and incentive structures. The authors point out that in the literature there is a noticeable degree of centralization that characterizes the governance of digital platforms. They add that many questions are yet to be answered regarding DLTs ability to deal with some of the fundamental issues of concern such as scalability, openness, interoperability and standards, liability and resilience, transparency and security. These issues should be continually addressed in order for blockchain to achieve widespread adoption in financial services.
• In Ethereum network users are not obliged to identify themselves in any way and can only be traced through their alphanumeric address, thus being pseudo-anonymous. For SWIFT, trust derives from being an acknowledged member of a private, centralized network, whereas, in the case of Ethereum and Bitcoin, trust is created by relying on the blockchain protocol.
• About Smart contracts, they should be designed in confidence to adopt DLT wholesale across their business.
• There is the need of boundary-crossing research.
Emanuel Palm, Ulf Bodin, and Olov Schelén (2020)
• According to the authors Disruptors can be replaced by a system of negotiated token exchanges and non-mediated message passing. By using cryptographic signatures and hash pointers, such as R3 Corda, the authors ensured that messages sent directly between two peers can be proved to be authentic later to third parties.
• If the assumptions made by the authors are correct, their approach lowers the barriers to adoption of distributed ledger technologies for businesses, legal institutions and others in comparison to state-of-the-art solutions, such as Hyperledger Fabric or R3 Corda.
• Solutions such as Ethereum is able to facilitate code-controlled agents via a public and global process reminiscent of voting, which can be used to circumvent traditional third parties in certain situations. The authors mentioned that nothing similar could be achieved with the system design they proposed.

Table 6. Cont.

Dirk A. Zetzsche, Linn Anker-Sørensen, Maria Lucia Passador & Andreas Wehrli (2022)
• DLT-based systems allow for the creation of foundational infrastructure linking existing systems rather than merely new designs on the front-end. The authors identified the Best Execution DLT, the DLT as Network of Central Banks, the DLT as AML/KYC Utility, Identity Platform, Small Payments Platform and Interoperability Platform connecting multiple closed-loop and proprietary banking systems. • DLTs need ongoing coordination across, and governance arrangements among the nodes. Further, in a crossborder context multiple regulators and courts in various countries (demanding compliance with their own set of rules and regular reports) will be involved. There should be responsibility and accountability for all legal obligations related to each function and activity. • Ledger operators must specify subject to regulatory approval to which rights and obligations the ledger perspective applies; in the absence of such, the rules apply based on the node perspective. For systemic risk controls, AML/CTF, data protection and governance, as well as DLT governance and, the authors proposed an inverted default rule in which the ledger perspective prevails.
Petri Honkanen, Mats Nylund and Magnus Westerlund (2021)
• Blockchain governance is significantly different in nature from many other forms of governance. The academic literature lacks a comprehensive approach to blockchain governance to understand how decentralized organizations considers the topic. • The authors point out that: *"Governance: a structure of processes, rules, and procedures (human activity) meant to maintain a decentralized ecosystem, is missing in an explicit form in a large number of the examined white papers"*. The researchers found 67 relevant white papers to use as primary data in this study. The relevance was determined by the existence or nonexistence of discourses concerning governance. According to the authors, basic units of governance are named as features. Furthermore, no white paper that was analyzed covers all the discovered features. An all-encompassing examination of descriptions of governance cannot be found in any white paper. • According to the authors, the following objectives of Governance: governance as a guarantee against the centralization of a network, democracy as a target itself and decentralization as a target can only be implemented without a remnant of centralized power. • The authors found some Governance mechanisms that set proposals, voting, tokens, sanctions, reputation or participation records, constitution, consensus, and validating. Governance mechanisms are used to maintain, update, and upgrade the ecosystem and the ledger itself. Stakeholders may have different interests and values for introducing governance mechanisms, and these interests may be incompatible or competing among them. • Decentralized ecosystems must consider formal proposing, decision making, and execution mechanisms. There are profound differences between centralized and decentralized ecosystems, mainly emerging from a governance perspective.
Roman Beck, Christoph Müller-Bloch, and John Leslie King (2018)
• The authors claim that transactions that are enforced autonomously, following rules in smart contracts, look quite different than transactions in the digital economy. • The authors consider a case study of an emerging DAO examines the blockchain economy, and the implications for governance. Additionally, They consider a research framework and agenda for IT governance in the blockchain economy.
Bokolo Anthony Jnr [1] (2022)
• DLT adoption deals with governance challenges. Additionally, extended enterprise lacks an understanding of how to govern DLT-based platforms. Furthermore, the governance of DLT is vital for the sustainability of extended enterprise as it enables stakeholders to make decisions. • Based on secondary data from the literature a framework is developed to support the governance of DLT to help researchers, practitioners, and managers alike to design and manage DLT platform ecosystems towards creating competitive value for all participating stakeholders in the DLT ecosystem. • More research needs to be done regarding factors that impact the governance of DLT in enterprise context to derive variables for conceptualization of a DLT governance model.
Konstantin D. Pandl , Scott Thiebes , Manuel Schmidt-Kraepelin , And AliSunyaev (2020)
• Results reveal multiple future research opportunities in interdisciplinary field for both, theory- as well as practice-oriented research. The authors considered both perspectives, AI for DLT, and DLT for AI and the many different concepts of their integration. • Considering the convergence of DLT and AI, the paper contributes to the development of future innovations.

Table 6. Cont.

David Petersen (2022)
• Blockchain technology influences the usage of the traditional contractual and relational mechanisms of governance. Furthermore, blockchain application can specifically substitute for the traditional mechanisms themselves. • The ability of blockchain to deliver this automated hierarchy of governance mechanisms may allow a reevaluation of existing theories of inter-organizational governance.
Vittorio Capocasale, Danilo Gotta, Guido Perboli (2023)
• The authors call attention to the fact that many blockchain frameworks have emerged in the last few years, hence choosing the most suitable framework is often a challenging task due to the possible lack of updated comparative analyses. • The researchers conclude that blockchain Fabric is efficient but lacks a BFT consensus algorithm; Sawtooth is flexible but not as efficient; and finally, Quorum performs well, offers a BFT consensus algorithm, and supports private transactions.
Patricia C. Franks (2020)
• The author offers a six-stage blockchain records consideration model as an analytical resource for records managers and information governance professionals in both business and government to refer to when adopting a blockchain technology. The six-stages are: (1) off-chain activities, (2) creation activities, (3) storage and distribution, (4) access and use, (5) on-going compliance and maintenance, and (6) disposition (including transfer to archives).
Victoria L. Lemieux, Chris Rowell, Marc-David L. Seidel, and Carson C. Woo (2020)
• The authors point out the need to make decisions about the adoption of distributed trust technologies within a risk management framework that considers both a threat-based as well as a strategic business approach. • A strategic business risk perspective on information governance would have to weigh factors related to the adoption of distributed trust technologies and the strategic business interests. The adoption of the distributed ledger technology must be aligned with business strategy and expected goals. • The distributed trust technology has the potential to introduce some types of risks when decentralizing as it potentially transforms the context of records systems and processes. • The authors consider that one of the main risks will be caused by misalignment of institutional trust and accountability frameworks. . Trust and accountability frameworks may remain centralized while records and information systems and processes are decentralized.
Rodrigo Dutra Garcia, Gowri Sankar Ramachandran , Raja Jurdak , and Jo Ueyama (2022)
• The authors presented a decentralized data governance framework for e-prescription that uses proxy re-encryption and smart contracts to let data owners control and manage their data through a trusted and transparent blockchain platform. The authors were able to show how the data owners can record all the access requests and consents in an immutable ledger to monitor data lineage. • The authors adopted a proof-of-concept implementation which uses CosmWasm, Hyperledger Besu, Ethereum, pyUmbral proxy re-encryption, and BBS signatures library to assess the feasibility and performance. Results show that the proposed architecture can protect data owners' privacy and govern sensitive data access with minimal overhead. Author´s data governance framework is application-agnostic, and hence, it can be explored in any multi-stakeholder applications that deal with sensitive and private digital data.
Bokolo Anthony Jnr [2] (2022)
• The study presents factors associated with governance of distributed ledger and decentralized technologies adoption. A governance model is developed to enhance the governance of distributed ledger and decentralized technologies adoption to accelerate the digitalization of organizations operations. Propositions related to Governance are grounded on the economic, technological, political, and social factors that infuence the governance of DLT in organizations.

Source: Authors.

Figure 02 below summarizes the main features (or terms) related to governance for Distributed Ledger Technology (DLT). These features were extracted from the papers read (listed on tables 05 and 06).

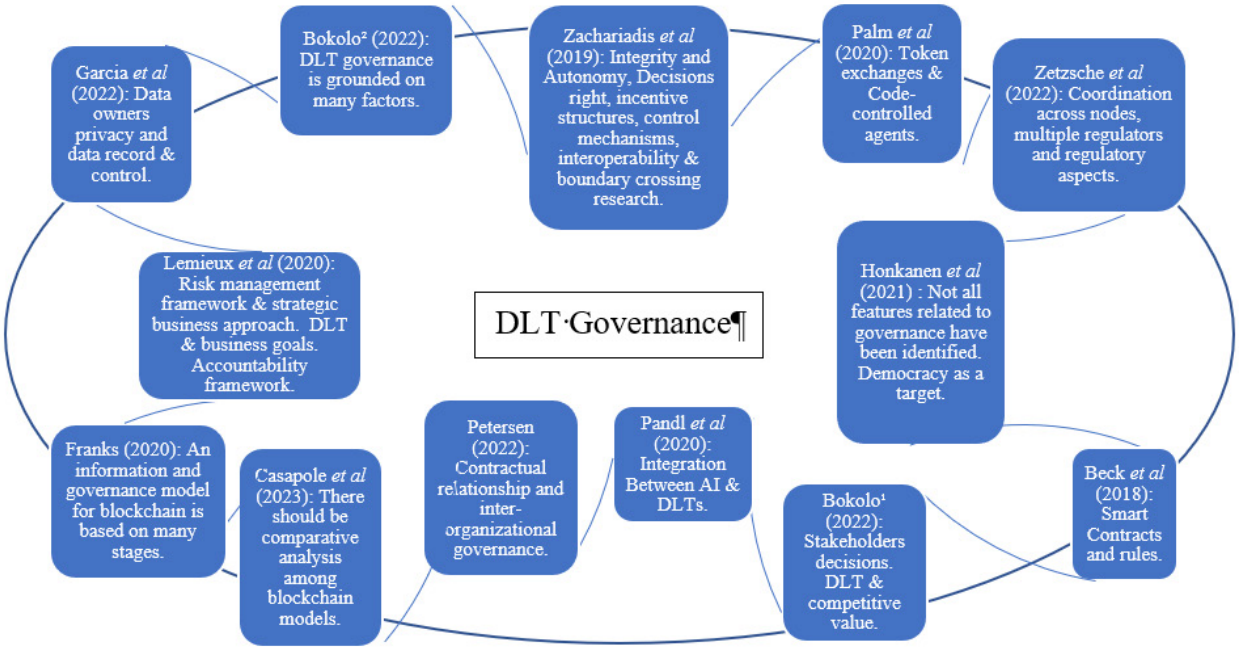


Figure 2. Main Features related to DLT Governance.
Source: Authors.

DISCUSSION, FUTURE RESEARCH & LIMITING FACTORS

This paper's main objective is to identify and compile the state of the art in literature about IT governance related to Distributed Ledger Technology (DLT). Additionally, these findings may help identify governance aspects related to interoperability among different protocols. Reaching fully these mentioned aspects this paper would have achieved its research goals completely. However, discussions should consider what was found. Firstly, the theme of DLT is a new field to literature and as results show, the literature is still exploring and maturing research about IT governance for DLT systems. This observation is specially claimed by Honkanen et at (2021). The authors found that no white paper that was analyzed covers all the discovered features about governance. An all-encompassing examination of descriptions of governance cannot be found in any white paper selected by the authors throughout their research.

The main observations extracted from the papers analyzed mention that many features must be considered when talking about DLT governance (Zachariadis *et al*, 2019). Tokens and codes can be used as controls (Palm *et al*, 2020). Coordination across nodes and multiple regulatory aspects (Zetzsche *et al*, 2022). Democracy should be a target and not all features about governance have been identified (Honkanen *et al*, 2021). Smart contracts and rules play an important role (Beck *et al*, 2018). Stakeholders' decisions and competitiveness regarding the use of DLT is an important point to be further explored (Bokolo¹, 2022). It is possible to have the integration between AI and DLT (Pandl *et al*, 2020). Contractual relationships are linked with governance (Petersen, 2022). Comparative analysis among blockchain models is necessary to help decisions (Casapole *et al*, 2023). A governance model is structured in many stages (Franks, 2020).

A risk management framework, along with a strategic business approach and accountability considerations should be applied when using a DLT (Lemieux *et al*, 2020). Data privacy, record and control must be considered regarding data owners (Garcia *et al*, 2022). DLT governance is grounded on many factors (Bokolo[2], 2022).

As results show, literature has explored not only IT or general technological governance but also all pillars about governance. Additionally, most of the studies explore the DLT governance rather than the IT governance about DLT systems. This point enables to observe that due to DLT features the IT governance is merged in the whole governance aspects. For one aspect it was not found enough answers, and this is the point of governance related to interoperability when interconnecting different DLT platforms (as illustrated in figure 1). Hence, this point is our main recommendation for future research.

Although this field of research is something new, this may not be listed as a limiting factor. Overall, this study did not have an outstanding limiting factor. However, there is a lack of results bringing papers covering interoperability and complex DLT protocols interactions focusing on IT governance. Additionally, there is also a lack of papers exploring assets tokenization and its respective IT and/or DLT governance.

CONCLUSIONS

The literature has explored not only IT or general technological governance but also all pillars of governance for Distributed Ledger Technologies (DLTs). Furthermore, most of the studies explore DLT governance as a whole rather than IT governance itself. Governance for DLT has many features and stages, such as compliance, technology, interoperability, accountability, design, financial aspects, democracy, data usage, transparency, stakeholders´ needs, among other points. It is possible to assume that many features about governance for DLTs have already been noticed by literature. However, literature lacks more research regarding specifically the interoperability (along with IT) governance for complex interconnections among different DLT protocols. Furthermore, there is also a lack regarding the technological governance aspects for interconvertibility among assets. Therefore, this paper claims the message that the complex interactions illustrated in figure 1 (Introduction) should be further understood, once DLT (along with its IT governance) is the basis for DeFi, CBDCs and Tokenized assets.

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