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Investigating the Decentralized Governance of Distributed Ledger Infrastructure Implementation in Extended Enterprises

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Abstract
Distributed ledger technology (DLT) is a disruptive technology with the potential of improving extended enterprise (EE) which comprises organizations that combine their capabilities and knowhow to achieve a common goal. Within the extended enterprise, governance enables distributed ledger control and stewardship and provides effective ways for enforcing ledger access and ownership policies. Although research related to DLT has received attention from academics and industries, the decentralized governance perspective of DLT remains less explored, and it is uncertain how decisions are made concerning the deployment of DLT within EE. These call for governance policies to protect the interests and needs of all stakeholders within the extended enterprise. Therefore, there is need for research that provides insight regarding the decentralized governance of DLT, showing how stakeholders and actors within EE make informed decisions. Accordingly, grounded on academic literature, this study develops governance of DLT framework for extended enterprises which comprises DLT governance dimensions, stakeholder/actors, and DLT governance mechanisms. The findings also present the governance actors and categories of DLTs, potentials, and challenges regarding decentralized governance of DLT in extended enterprises. Findings provide implications to enterprises, researchers, practitioners, industries, and policymakers on the concept of decentralized governance for organizational transformation. Finally, findings from this research are instrumental for designing governance policies to support DLT implementation and stimulate potential research within this direction.

Keywords Digital infrastructures · Technological innovation · Disruptive technology · Decentralized governance · Distributed ledger infrastructure · Extended enterprises

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Introduction

A distributed ledger technology (DLT) is a digital ledger that records all the transactions that occurs in an immutable and decentralized manner. It comprises multiple components (e.g., hardware, software, protocol) that are developed and governed by different group of actors (Fan et al., 2020). DLT have now developed far beyond cryptocurrencies used for managing transactions in many fields and applications, such as payment handling in financial and insurance industry, managing logistics in supply chain industry, and tracing goods in the transportation industry. Over the years, an increasing number of corporations termed extended enterprises (EE) have emerged among enterprises to leverage the potential of their individual capabilities and resources to achieve real business value (Anthony Jnr & Abbas Petersen, 2021; Browne & Zhang, 1999; Jagdev & Thoben, 2001). Extended enterprise (EE) comprises an alliance of organizations aimed at achieving a common goal in an approach that aligns to a shared consensus (Jnr et al., 2020; Jnr, 2020b). The realization of EE involves aligning interests between involved parties, so they are prepared to dedicate efforts, time, human and technical, and financial resources towards the joint goal (Lumineau et al., 2021).

Therefore, extended enterprises are investing considerable resources in developing different DLT-based applications to manage inter- and intra-organizational collaborations on both physical and digital assets (Al Hadidi & Baghdadi, 2019; Jnr, 2020a). Findings from Zavolokina et al. (2020) stated that 18% of organizations are currently involved in EE that adopts blockchain, 45% are interested to join an EE, and 14% or organizations are considering creating one. Recently, organizations such as Standard Chartered Bank, AIG, and IBM initiated an extended enterprise aimed at creating a global insurance policy based on DLT such as block chain. In this alliance, DLT enables the provision of a real-time shared version of all policy data to all companies involved. By deploying DLTs such as blockchain, extended enterprises can record and track business events across each country linked to the insurance policy for automated execution of payments when predefined conditions are met. In comparison with other forms of information exchange, DLT facilitates all permissioned organizations to retain a unified view of the data, while no single enterprise can make modifications without the consensus of the other partners (Lumineau et al., 2021; Zhu et al., 2021). However, the development of DLT adoption in extended enterprises is dependent on the deployment of effective governance consensus mechanisms (Hofman et al., 2021).

Governance is defined as a mechanism that sets how organizational rules and incentives are initiated, or the strategic use of power is enforced (Hofman et al., 2021; Lumineau et al., 2021). Governance denotes the framework for accountabilities, decision rights, democracy (Carayannis & Campbell, 2014, 2021), and incentives to encourage desirable behavior in the utilization of resources (Weill, 2004), whereas governance mechanisms establish how responsibilities, communication, and decision-making structures are enacted (Morawska-Jancelewicz, 2021; Weill & Ross, 2004). Governance also involves human-centric and techno-centric

innovations (Carayannis et al., 2021a, b) to improve smart services within the enterprise process (Momeni et al., 2019). Likewise, DLT governance describes the mechanisms that enable the decentralized infrastructure to adapt and evolve over time (Fan et al., 2020). Hofman et al. (2021) stated that decentralized DLT governance defines how power is managed within distributed infrastructure. Findings from the literature suggest decentralized DLT governance can be categorized as governance by DLT (achieved via the adoption of DLT to address governance issues faced in technology adoption) and governance of DLT (managed by stakeholders, actors and the community of developers involved with the DLT) (Hofman et al., 2021). This current study is more aligned with "governance of DLT" as the governance categories, actors, consensus mechanism, etc. involved in governing DLT implementation in enterprise enterprises are explored.

In the context of this study, the governance of DLT can help to identify stakeholders and actors collaborating within EE (Lumineau et al., 2021). Often DLT is coupled with automated self-governance; i.e., the governance of the technology is embedded within the infrastructure through consensus mechanisms (Rikken et al., 2019). Although the adoption of DLT has gotten increasing attention over the years, the topic of DLT governance often remains less understood (Fan et al., 2020). Governance has received little attention in DLT domain, and there is fewer literature on the governance of DLT platforms in extended enterprise domain (Hofman et al., 2021). Although the decentralized nature of DLT increases the opportunities for enterprises to collaborate and coordinate their business process as extended enterprises, the decentralized governance structure of DLT is not completely democratic. Hence, there is need to investigate how to achieve a distributed governance of DLT infrastructure without assigning specific privileges or powers to a few identified actors or stakeholders (De Filippi, 2019).

Therefore, this article aims to provide a descriptive finding grounded on secondary data from the literature for understanding DLT governance in extended enterprises, from which implications for policy and practice are drawn to further DLT implementation in the society. This study provides a deeper understanding to practitioners, researchers, industries, and regulators on how they can design effective governance systems for DLT. Additionally, this study identifies DLT governance challenges and provides recommendations on how DLT governance can be improved. This article is structured as follows. In the next section, the literature review is presented followed by the method employed in "Method" section. Then, the findings are presented in the "Findings" section. The "Discussions" section highlights the discussions, and the "Theoretical and Practical Implications" section is the implications. Finally, the "Conclusions" are presented.

Literature Review

DLT governance has become a major theme in enterprises since the Ethereum hard forks incident. To this end, a few studies have been focused on addressing DLT governance issue over the past years. In this section, some of these studies are highlighted. One of the studies was carried out by Hofman et al. (2021)

where the authors explored blockchain governance. The authors aimed to provide more discussion regarding blockchain governance not primarily focused on the technical aspects only. Lumineau et al. (2021) examined blockchain governance and provided a novel medium for organizing collaborations. The authors outlined the chronological background, main features, and mechanisms of blockchains in relation to governance role. The researchers further explored how blockchains may change how collaborations are organized, including different forms of blockchains that may emerge, and other important issues related to organizational development. An interesting study by Pelt et al. (2021) provided a framework for definition of blockchain governance based on six dimensions (formation and context, roles, incentives, membership, communication, and decision-making) and three distinct layers (off-chain community, off-chain development, and on-chain protocol). The framework was evaluated through two case studies and eight expert interviews.

Another study by De Filippi et al. (2020) researched the problem of trust and challenges of governance associated with blockchain. The researchers maintained that blockchain is not a trustless technology but more accurately a confidence machine. In addition, the study employed the constitutional, legal, and polycentric governance theory to identify governance challenges faced in blockchain-based platforms. Lee et al. (2020) provided an earlier pre-print which explored the political economy of blockchain governance. The authors designed a model of blockchain governance using tools grounded on formal political theory. The model describes counter-intuitive occurrences that have been observed in the governance of blockchain platforms. Ziolkowski et al. (2020) researched on decision problems associated with blockchain governance. Their study explored fourteen blockchain platforms from four application lens. Data was collected from the literature and via semi-structured interviews to identify common problems within blockchain governance to enrich limited studies on the governance of blockchain platforms.

Rikken et al. (2019) presented the governance issues of blockchain and decentralized autonomous organizations (DAOs). The authors identified potential issues regarding governance of blockchain schemes in several types of decentralized systems based on literature review and case study research. They clustered the governance challenges as a framework which comprises layers (company, application, infrastructure, and institution or country) and stages (operate, design, and evolve or crisis). Beck et al. (2018) investigated governance within the blockchain economy and presented a framework. The author grounded their framework within the sphere of IT governance variables which includes incentives, accountability, and decision rights. The authors linked their study to DAO case study to demonstrate that governance within blockchains may change radically from well-known notions of governance. Meijer and Ubacht (2018) investigated the governance of blockchain platforms grounded on an institutional perspective to offer insights into the governance of blockchain infrastructure. Also, institutional perspective provided public and private actors within the blockchain systems to initiate regulatory strategies and fostering power and possibilities that blockchain systems offer. Reijers et al. (2018) explored off-chain and on-chain governance of blockchain technologies to address blockchain governance issue. Their study

illustrated some of the inherent vulnerability and problems associated with the application of on-chain governance with reference to a mishap in the DAO blockchain-based system.

The reviewed studies explored different perspectives towards improving DLT mainly governance of blockchain. However, based on the reviewed 10 studies, not one of these studies explored DLT governance mainly in enterprises such as extended enterprises which collaborates to achieve similar goals. Even though these studies provided evidence on governance of blockchain, most of the existing literature on governance of DLT are mostly not aligned to real-world governance of extended enterprise adoption of DLT platforms. For example, studies that identified the decision rights, responsibilities, roles, and possible incentives of stakeholders and actors in DLT-based system are yet to be explored (Ziolkowski et al., 2020). This gap in knowledge and the practical significance highlights the motivation for this current research. Therefore, there is need for a study that fills this gap in knowledge which explores governance of DLT in extended enterprises.

Method

A structured literature review was carried out based on the systematic literature review approach by Anthony Jnr (2021b). A structured literature review aims to expediently assess prior studies that are appropriate to the specific research topic to present a fair assessment of an investigated topic using a rigorous and trustworthy approach. Therefore, the research flow for this study comprises five phases as shown in Fig. 1.

Figure 1 shows the research flow for this study, where each phase is discussed below in the subsequent sub-sections.

Inclusion and Exclusion Criteria

The inclusion and exclusion criteria are the sampling approach employed to select peer reviewed articles to explore governance of DLT in extended enterprises. The inclusion and exclusion criteria are stated in Table 1. Thus, peer-reviewed articles are included if they meet up to the criteria in the inclusion column and are excluded if they satisfy any of the exclusion criteria.

Fig. 1 Research flow

Table 1 Inclusion and exclusion criteria

Inclusion	Exclusion
• Should provide background on the governance of DLT/blockchain in extended enterprises	• Studies that do not present background on the governance of DLT/blockchain in extended enterprises
• Should be based on an approach, model, theory, and framework for achieving governance of DLT/blockchain	• Models, approach, frameworks, or theories used in contexts other than governance of DLT/blockchain
• Should be mainly written in English and published between 1999 and 2021	• Studies not within 1999 to 2021 and are not written in English
• Studied on DLT/blockchain governance, governance categories, governance consensus mechanism, governance challenges, and governance recommendations	• Studies not on DLT/blockchain governance, governance categories, governance consensus mechanism, governance challenges, and governance recommendations

Search Strategies and Data Sources

The sources employed in this study were retrieved through a comprehensive search of prior governance of DLT in research through online databases which comprise of Google Scholar, Wiley, Taylor & Francis, IGI Global, ScienceDirect, Sage, Emerald, IEEE, ACM, Inderscience, and Springer. The search was undertaken within June 2021. The search terms include the keywords ((“governance of distributed ledger technology” OR “DLT governance” OR “distributed ledger technology governance”) AND (“governance of blockchain” OR “blockchain governance” OR “consensus mechanism of DLT” OR “consensus mechanism of distributed ledger technology” OR “consensus mechanism of blockchain” OR “enterprises”) AND (“governance categories of blockchain” OR “governance categories of distributed ledger technology”)). These keywords were employed to retrieve appropriate articles to provide empirical evidence regarding governance of DLT in extended enterprises.

Figure 2 shows the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) flowchart which was used for screening of articles as previously utilized by Anthony Jnr (2021a). The final search resulted to 70 peer-reviewed articles using the keywords above. No articles were established as duplicates. Thus, the articles remained 70. The articles were checked against the inclusion and exclusion criteria, and 25 sources were excluded since they were not related to governance of DLT in extended enterprises resulting to 45 articles. The remaining articles was checked for quality assessment. A check was carried out to verify if the articles were indexed in Scopus or/and ISI Web of Science databases. The findings as discussed in the quality assessment section suggest that the selected studies meet the inclusion and quality assessment criteria. Lastly, 11 articles were included via cross referencing as seen in Fig. 2. All included sources are presented in the reference section of this paper totaling to 56 sources.

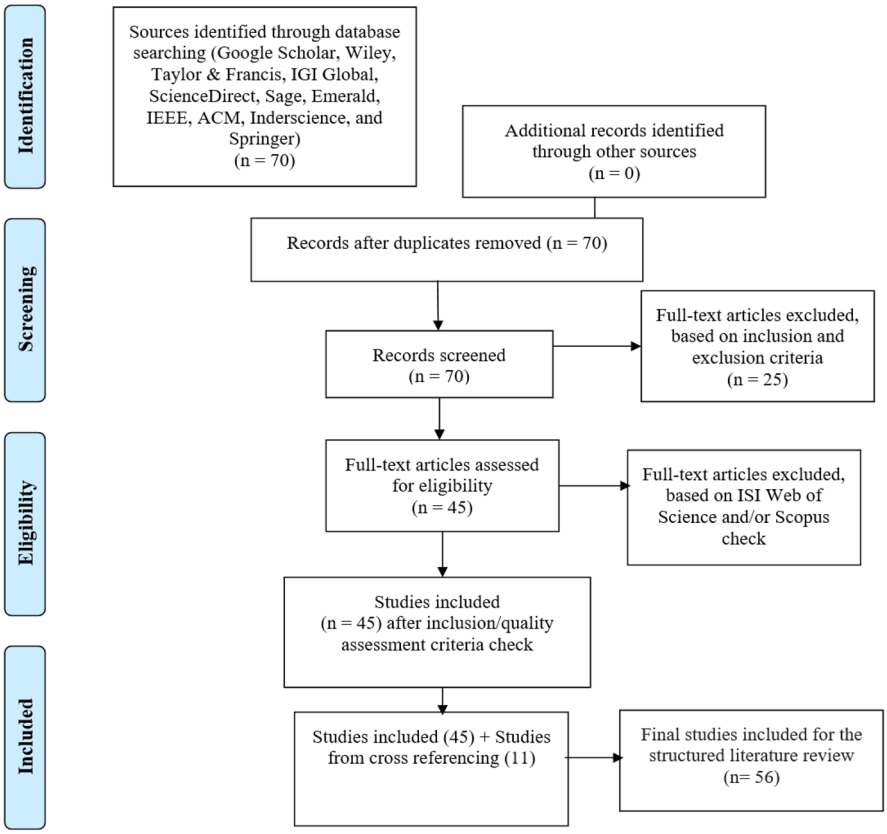

Fig. 2 PRISMA flowchart for the selected articles

Quality Assessment

One of the important benchmarks that is required to be checked with the inclusion and exclusion criteria is the quality assessment check as recommended by Anthony Jnr (2021b). Therefore, quality assessment check was employed for all selected peer-reviewed articles to confirm if the papers are indexed in Scopus or/and ISI Web of Science database as previously stated. This criterion helped to evaluate the quality of the selected studies. Besides, more than half of the articles included are indexed in Scopus or/and ISI Web of Science database.

Data Coding and Analysis

The selected 56 peer-reviewed articles are utilized to provide evidence in response to the governance of DLT in extended enterprises. This helps to provide information on DLT governance dimensions, stakeholder/actors, DLT governance mechanisms,

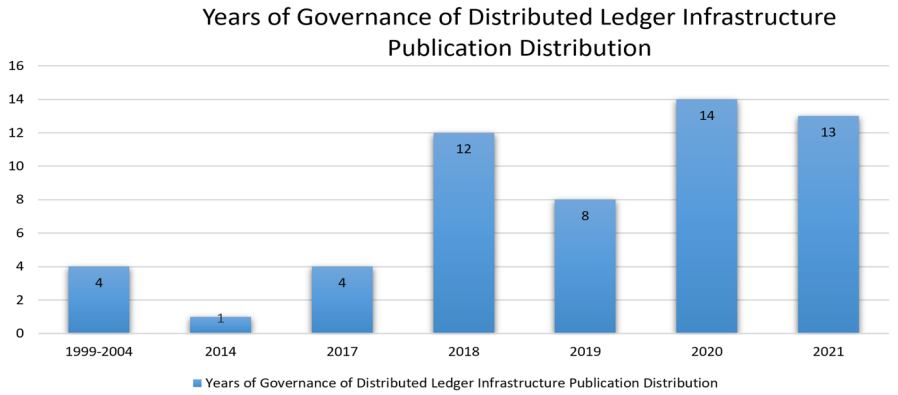

Fig. 3 Distribution of governance of distributed ledger infrastructure articles in years

governance actors, and categories of DLTs. Also, information on the potentials and challenges regarding DLT governance in extended enterprises. Thus, secondary data is extracted and synthesized in detail and evidence from these sources as related to governance of DLT in extended enterprises.

Findings

This section provides findings based on the selected 56 peer-reviewed articles included for this study related to governance of DLT in extended enterprises.

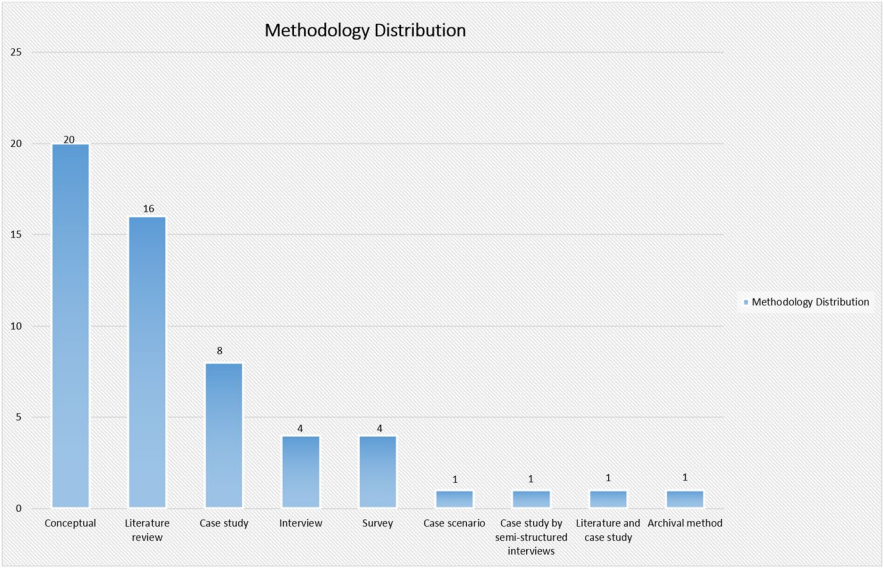

Fig. 4 Distribution of selected articles in terms of methodology

Year of Publication, Methodology, Countries, and Contexts

Findings from Fig. 3 indicate that the selected studies ranged from 1999 to 2021. Findings suggest that more studies related to governance of DLT were published in 2020 as compared with the other years.

Considering the methodology applied in selected studies, findings from Fig. 4 show that conceptual grounded studies are the most employed method ($N=20$). Next are studies based on literature review is with ($N=16$). Following are studies that are based on a case study with $N=8$ and studies that employed interview and survey for validation ($N=4$), respectively. The remaining studies ($N=1$) employed other methods as seen in Fig. 4.

Regarding the studies, the country distribution of all authors in terms of the frequency is illustrated in Fig. 5. The findings suggest that most of the authors that researched on governance of DLT are based in the United States of America, The Netherlands, Norway, the UK, Malaysia, France, Australia, Austria, Germany, Ireland, Canada, Iran, and Switzerland as compared to other countries. The numbers represented in Fig. 5 are however higher than 56 as most articles have more than one authors from different countries. Considering the selected studies' context distribution for governance of DLT, the findings as seen in Fig. 6 suggest that most

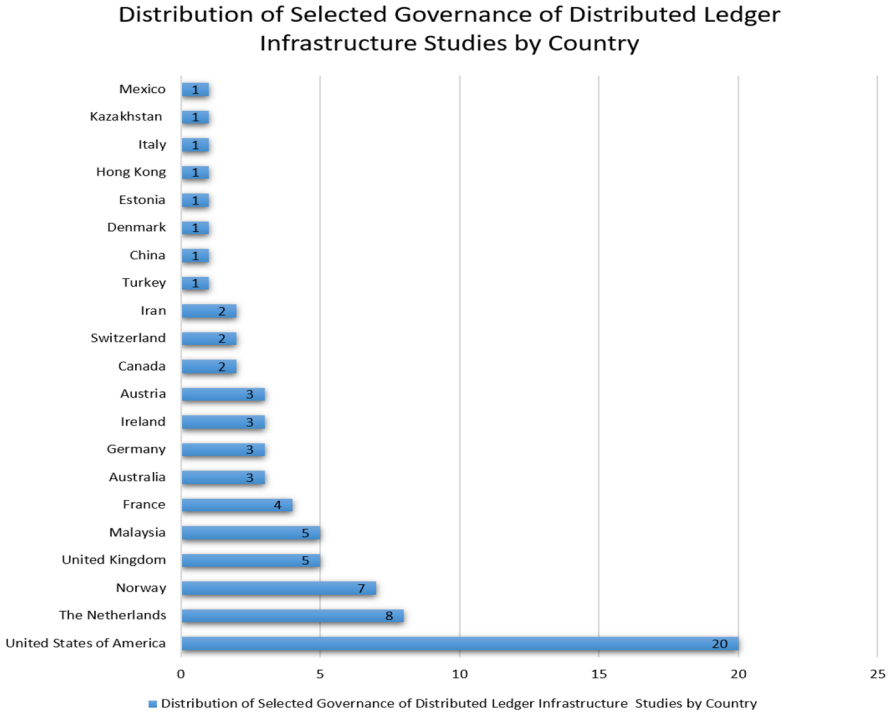

Fig. 5 Distribution of selected studies by country

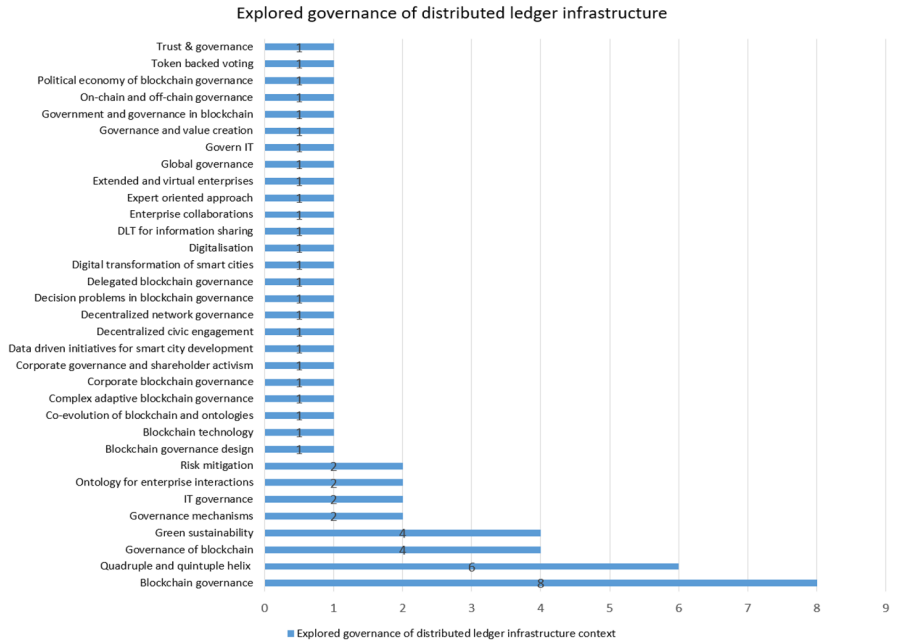

Fig. 6 Distribution of context explored by selected studies

researchers explored blockchain governance and governance of blockchain as compared to other contexts. Likewise, Fig. 7 shows the distribution of selected enterprise sector context, where most of the selected studies on governance of DLT are more aligned to general enterprise context. Only one study is conducted in extended and virtual enterprise domain. This shows there is need for studies that examines governance of DLT in extended enterprises. Therefore, this current study adds to the existing body of knowledge by investigating the decentralized governance of distributed ledger infrastructure implementation in extended enterprises.

The Role of Distributed Ledger Infrastructure in Extended Enterprises

The notion of extended enterprise has lately been employed in businesses to embody high-level cooperation between different businesses (Browne & Zhang, 1999; Jagdev & Thoben, 2001). Extended enterprise denotes two or more companies that desire to extend their operations to other industries to improve their competitiveness and enhance their existing resources (Al Hadidi & Baghdadi, 2019). It represents a new type of inter-organizational collaboration where businesses contribute their individual resources to address business problems (Anthony Jnr, 2021b; Zavolokina et al., 2020). These organizations engaged collaboratively in the design, development, distribution, and production of a product and services to customers. EE aims to achieve reduced cost, on-time delivery of products, or improved the quality of

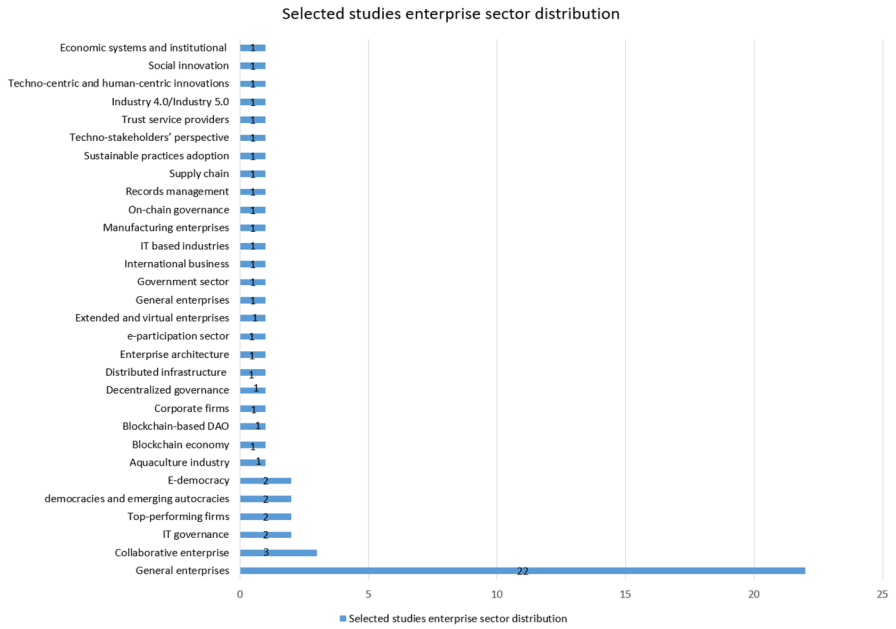

Fig. 7 Distribution of selected enterprise sector context

goods (Anthony Jnr & Abbas Petersen, 2021). EE aims to address unreliable and inconsistent data stored by several organizations in remote databases, incurred cost and faced within business processes, and lack of trust and transparency between individual members (Zavolokina et al., 2020). Presently, extended enterprises are adopting DLTs to develop novel business goals. The implementation of DLT is changing extended enterprise processes and the way these organizations transact across borders, enabling businesses to collaborate outside the reach of current regulations and governance mechanism (Hooper & Holtbrügge, 2020).

The complex nature and variety of this form of inter-organizational alliance combined with increased use of DLT in enterprises calls for deeper investigation of the role of DLT in EE. Thus, extended enterprises such as insurance, banking, energy, healthcare, and transportation are deploying DLT to adapt and survive (Pelt et al., 2021). The financial sector is one of such enterprises which has invested about 1.4 billion USD on research into DLT (De Filippi et al., 2020). Also, fintech startups, for example, Ripple, aim to modernize global payments with the use of DLT. Executive banks such as Deutsche Bank are beginning to implement blockchain across their portfolios, and well-known technology firms such as Facebook have initiated their own cryptocurrency Libra (Schmeiss et al., 2019), which is being utilized to provide alternative payment to PayPal or credit cards. Beyond that, DLT is being implemented in many other enterprises such as IBM, Deloitte, and Samsung, to automate and simplify payment and track wholesaler loyalty points. Extended enterprises such as IBM and Maersk are also adopting DLTs to improve supply chain management (Hooper & Holtbrügge, 2020).

Another extended enterprise is the collaboration between HTC, Siemens, and others electricity in providing energy sharing and grid management in blockchain-supported phones to make payment in cryptocurrency. Toyota has merged with R3 blockchain consortium to improve tracking of auto parts across factories in different countries. This helps to improve the efficiency and logistical issues associated with value chain disruptions. Another partnership is between IBM and Walmart where the two enterprises cooperate to track the supply of food products exclusively in Walmart's supply chain management. IBM is also in partnership with Everledger, where diamonds are being tracked and recorded from the mining location to the jewelry chain store (Hooper & Holtbrügge, 2020). Additionally, there is a recent coalition among automotive firms (Renault, Ford, BMW, and General Motors) aimed at adopting blockchain to streamline their transactions within the automotive industry. This alliance initiative aimed to create a viable digital mobility ecosystem towards a common standard for adopting blockchain within the automotive industry to support vehicle identity tracking and data ecosystem management (Katina et al., 2019).

Governance of Distributed Ledger Infrastructure in Extended Enterprises

Decentralization governance of DLT aims to achieve a more egalitarian adoption of technology where power shifts from centralized powers to a decentralized group of actors, enabling a more even distribution of control. Decentralized governance leads to increased public engagement and participation and ultimately aids decision-making that promote the public concern (Junior et al., 2018). Governance defines the processes by which entities with ongoing relationships such as extended enterprises negotiate regarding how to adapt to changes (Allen & Berg, 2020). Governance determines what and how decision-makers are to be made responsible (John & Pam, 2018). Governance entails how actors collaborate to develop, execute, and evolve inputs and processes that make up a DLT system. Governance is the procedure by which new functionalities are suggested, developed, agreed upon, and executed (DiRose & Mansouri, 2018). Therefore, governance can be theorized as the medium by which to instill order and to lessen conflict and achieve mutual gain (Anthony Jnr, 2021a). It aims to stimulate benevolence and to ensure economical outcomes by applying fiscal and regulatory mechanisms (Hooper & Holtbrügge, 2020), towards the actualization of a desired short-, medium-, or long-term goals (Katina et al., 2019).

The authors Ølnes et al. (2017) and De Filippi and McMullen (2018) highlighted that there is a difference between governance of DLT and governance by DLT. Firstly, governance by DLT refers to the use of DLT to provide a supporting role towards improving binding decision making processes (Llamas Covarrubias & Llamas Covarrubias, 2021), for instance, when DLT is deployed to implement and automate existing enterprise processes. On the other hand, governance of DLT encompasses the development, adaptation, and maintenance of DLT infrastructure. The governance of DLT is the main interest of this study similar to prior study (Pelt et al., 2021). In this article, "governance of DLT" refers to the means of achieving the control, direction, and management of stakeholders involved within the context

of a DLT-based platform (Pelt et al., 2021). In extended enterprises DLT governance mechanisms are deployed to ensure transactions are successfully carried out by creating and enforcing rules and restrictions on the involved companies (DiRose & Mansouri, 2018).

Although there is no one size fits all framework for understanding DLT governance. Governance of DLT is frequently not fully technological enforced, nor automatically self-governed as popularly believed (Ehrenberg & King, 2020; Rikken et al., 2019). The governance of DLT specifies how transactions are performed within the ledger, at what pace new data are added to the ledger, and what size is allocated to new data. Governance of DLT enables actors involved in DLTs to determine how software protocol, rules, and updates are to be employed within the DLT (Lee et al., 2020; Pelt et al., 2021). Governance of DLT is maintained through deployment of consensus mechanisms which executes fully autonomous protocol. The execution is implemented by the DLT infrastructure, the network nodes, which uses the consensus mechanism deployed for the DLT (Rikken et al., 2019). While the benefits of DLT in extended enterprises look promising, its implementation is still facing governance challenges (Pelt et al., 2021).

Besides, the actualization of decentralized governance is complicated both in theory and practice. This is because as more actors are involved in decision-making process, it becomes more difficult for all actors to agree on issues; as such, this leads to governance challenge (De Filippi & McMullen, 2018). But effective governance of DLT is also essential for successful adaptation, changes, and interaction. Furthermore, understanding how DLTs are governed is essential to come up with suggestions for policymakers (van Pelt, 2019). Nevertheless, researchers such as Pelt et al. (2021) state that there is a scarcity of topics of DLT governance.

Figure 8 depicts governance of DLT framework for extended enterprises which comprises of DLT governance dimensions grounded on IT governance literature (Weill, 2004; Anthony Jr, 2018; Beck et al., 2018), stakeholder/actors, and DLT governance mechanisms. Together, this triad of DLT governance dimensions, stakeholder/actors, and DLT governance mechanisms underpins the concept of DLT governance. Weill (2004) stated that governance dimension comprises of accountabilities, decision right, and incentives employed in the utilization of scarce resources. Grounded on IT governance, DLT governance provides the

Fig. 8 Governance of DLT framework for extended enterprises

model for accountabilities and decision rights to support desirable behavior in the use of DLT grounded on three main dimensions (incentives, accountability, and decision rights), as seen in Fig. 8 (Weill, 2004; Anthony Jr et al., 2018; Beck et al., 2018).

- In general decision rights determine the extent of centralization specifying whether decision-making control is determined by a single person or centralized group, or dispersed, or decentralized (Jnr et al., 2017). In governance of DLT, decision rights relate to the rights regulating control over specific assets (DLT system). Decision rights enable the generation and execution of decision proposals on how DLT system evolves. Decision rights control concern choice authorization (deciding when to deploy DLT decisions) and specify how decisions are checked (determining performance of decision actors within the DLT system) (Beck et al., 2018).
- In governance of DLT, accountability aligns to the right to monitor decisions made as regards to the operation of the DLT system. Actors within the DLT system need to be held accountable for their actions (Beck et al., 2018). Accountable addresses actions undertaken and consequences incurred by actors of DLT system. In DLT system, accountability is specifically legislated and enforced through smart contracts
- Incentives describe certain activities that encourage actors to act (Schmeiss et al., 2019). In DLT system, incentives can be financial benefits/monetized rewards or non-monetary rewards such as higher privileges, better visibility, or better reputation (Beck et al., 2018).

DLT governance mechanisms comprises access, control, and incentives seen in Fig. 8, each of which is discussed below:

- Access specifies which actor can participate in the DLT system and under which restrictions (Schmeiss et al., 2019). Access ensures that the actors with matching skills are cooperating within the DLT to create value. The platform leader specifies what types of actor can contribute in the DLT platform, links the actors, and assigns decision rights for certain actions to actors of the DLT platform (Schmeiss et al., 2019).
- Control refers to instituting shared rules among all actors and resolving possible conflicts of interest. Control defines the rules by which prospective actors in the DLT system interact (Schmeiss et al., 2019). Control mechanisms specifies the rules by which actors in the DLT system platform interact. It requires a clearly formulated set of conditions that allows actors to collaborate. In addition, control mechanisms ensure accountability for individual actors and ensure consensus in case of a conflict of interest (Schmeiss et al., 2019).
- Status is defined by the platform leader put in place to motivate participation and precise inter-actions of various actors to enable innovative outputs (Schmeiss et al., 2019). The more the actors are involved, the more higher status they have in the DLT-based system.

Governance of DLT entails complex interaction between stakeholders and actors which comprises founders, platform leader, and participants (extended enterprises), network validators, token holders, (such as economic full nodes and Bitcoin's miners), and application and core developers. These are the dominant actors who have a complete copy of the distributed ledger and are involved in the validation of the shared ledger. They decide whether to approve software versioning delivered by core developers depending on whether they consider that other nodes will accept new changes produced for the DLT system (Allen & Berg, 2020). Each of these stakeholders have a stake in the governance of the DLT system seen in Fig. 8. Although some stakeholders do not actively participate in the DLT network, they have interests in its evolution. These stakeholders include activists, media, government regulators, and social media seen in Fig. 8. DLT governance aims to address the challenge required to design and develop DLT platforms that balance the interests of all stakeholders and further ensure the success of the DLT infrastructure (Allen & Berg, 2020).

Governance Mechanism Control of DLT in Extended Enterprises

Researchers such as De Filippi and McMullen (2018); Allen and Berg (2020); and Fan et al. (2020) stated that the existing governance of DLT mechanisms control can be classified into two main categories: on-chain governance and off-chain governance as seen in Fig. 8. Likewise, findings from a recent study (Reijers et al., 2018) stated that the governance of DLT-based systems typically incorporates a variety of procedures and rules that may be applied both "on-chain" and "off-chain." On-chain governance simply describes rules and decision-making methods that have been programmed directly into the core infrastructure of a DLT-based system. This form of governance defines the rules of communications between participants via the infrastructure within which these collaborations occur. These interactions are exclusively defined by rules embedded within the underlying DLT code termed as "the rule of code" (Reijers et al., 2018). On-chain governance cannot be simply bypassed or avoided, because it is executed according to a pre-defined system of rules that have been programmed directly into the DLT system that is accountable for implementing them.

In on-chain governance, the stakeholder who are often referred to as token holders possess the autonomy to vote or accept if a new governance policy encoded within the DLT is to be accepted or rejected. Thus, on-chain governance describes the process of clearly developing governance policies into protocols, such as the implementations of Dash (Dash.org), Tezos (Tezos.com), and EOS smart contract which are typical blockchain platform based on the EOS cryptocurrency (EOS.IO), that allow certain groups of stakeholders to vote on modifications or suggestions (Allen & Berg, 2020). On the other hand, the off-chain governance necessitates informal coordination between stakeholders to decide whether certain changes within the DLT should be implemented. Recognized cryptocurrencies such as Ethereum and Bitcoin use the off-chain governance control in which core developers propose changes via formal improvement proposals and stakeholders organize the corresponding operations among core developers, miners, users, and node operators through community channels (Fan et al.,

2020). Off-chain governance generally defines governance structures external to the protocol, mainly the role and administration of enterprises sponsored by token sales or other associated token distribution (e.g., Zcash Foundation), or communal meeting platforms such as dedicated forums, Telegram, Twitter, Reddit, and Slack (Allen & Berg, 2020). Off-chain governance includes both exogenous and endogenous rules as well as all other non-on chain rules and decision-making procedures that may influence the operations and future development of DLT-based systems.

Off-chain governance is mostly approved by a reference community to guarantee the appropriate functioning and continuing development of a DLT-based system (Reijers et al., 2018). Off-chain governance allows for involvements into the DLT protocol that are not specified by the software protocol by external authorities. Accordingly, with off-chain governance, stakeholders oversee the code without their actions being established by it (Reijers et al., 2018). Nonetheless, off-chain governance introduces the issue of individual sovereignty (Reijers et al., 2018) and is often criticized for being relatively centralized as decision is based on core developers and miners which usually excludes the majority token holders from the decision-making, which has led to slower technological conservatism and advancement (Fan et al., 2020). Overall, on-chain governance appears to be the most desirable mode of governance for DLT-based systems since it ensures that no entity or group of people can enforce their will on the DLT community at large (Reijers et al., 2018).

Governance Actors and Categories of DLTs in Extended Enterprises

While a DLT platform is owned by no one and not particularly governed by no one (Pan et al., 2021). Generally, DLT-based platforms are socio-technological infrastructure which comprises of not only code, but also a variety of stakeholders or actors, including validators, miners, programmers, token and cryptocurrency holders, participants, and possible regulators (De Filippi et al., 2020; Li & Whinston, 2020). An actor is a user or any person, stakeholder, enterprise, or entity using DLT (van Pelt, 2019). Actors comprise a defined group of people with shared values and interests. In DLT systems, when the interest of actors differs, the users have the chance to branch out (often referred to as forking) and create their own community (fork) (Ziolkowski et al., 2020). In DLT-based system nodes usually participate for the right to process new data within the distributed ledger, thereby maintaining the operation of the DLT infrastructure. These nodes are mainly computers which are running the DLT's software and its core protocol.

These nodes store a complete version of the distributed ledger and authenticate that added ledgers are valid. There are normally mining nodes and lightweight nodes. The mining nodes refer to full nodes who also contribute to the consensus mechanism to publish new ledger data, whereas lightweight nodes do not store a full version of the ledger but pass on their information to the full nodes. Due to lightweight nodes constrained capabilities, they can be deployed on lightweight hardware such as IoT devices and smartphones (van Pelt, 2019). Additionally, there are miners or mining pools who provide and sell mining services and insurance to miners or cryptominers (Ferreira et al., 2019). These companies provide economic players

such as the big mining farms and mining pools and the popular online exchanges and DLT explorer who have now become central points of control in the governance of many DLT networks. These actors have significantly influenced the operations of DLT network and may likely leverage their power to further their own fiscal interests, either directly or indirectly (De Filippi et al., 2020).

The mining is operated by dedicated equipment that utilizes Application Specific Integrated Circuits (ASIC), which are chips developed to execute a particular function such as block mining. Other actors are the core or software developers and open-source contributors who can manage the evolution of the DLT-based network, by accepting or rejecting the introduction of new features into the technological design of the system. While most DLT-based infrastructure are open-source signifying that anyone is free to contribute code to the DLT platform. Yet, there are actors having conflicting interests, as regards to maintaining operation of the software which normally result to complex governance issues when it comes to updating the protocol of DLT. Besides, regulators might also be involved by either endorsing or objecting to the use of DLT-based platform.

As pointed out by De Filippi et al. (2020), the governance of DLT becomes a crucial concern as good governance initiatives need to be implemented to avoid some actors from operating in an untrustworthy approach, thereby destabilizing confidence in the DLT infrastructure. Governance of DLT can be categorized based on the rights nodes users are given to read the distributed ledger data or to administer transactions. The most categorization reported in the literature comprises of public contrasted with private and permissionless set against permissioned blockchains (Pelt et al., 2021). Therefore, the governance of DLT in EE comprises of public permissionless, public permissioned, private permissioned, and private permissionless as seen in Fig. 9.

Figure 9 depicts the categories of governance of DLTs in extended enterprises. Public as opposed to private refers to the visibility of ledger either to for everybody (public) or to specific people (private) (Rikken et al., 2019). A public DLT is a permissionless distributed ledger infrastructure that can permit read and write access to all node users who wish to join the distributed ledger network. These DLTs allow for wider access (Katina et al., 2019). In a public based DLT, there are no constraints regarding reading of ledger data or submission of ledger transactions (Pelt et al., 2021). A public DLT actors comprise of system developers, nodes, record producers, and designers or creators of the DLT system (Hofman et al., 2021). However, they are difficult to manage the privacy and they include Ethereum, Bitcoin, Lisk, and Dash (Katina et al., 2019).

A private DLT is an opposite of a public DLT as it does not restrict the reading of the distributed ledger data and the submission of ledger transactions is mainly limited a specific set of users (Pelt et al., 2021). A private DLT is a permissioned as it only allows permitted groups to join the DLT network. These DLT could be created for purposes and they include Ripple, Chain, and R3 Corda (Katina et al., 2019). Additionally, a difference between permissionless DLTs and permissioned DLTs specifies if any restrictions are enforced on the handling of transactions within the distributed ledger (e.g., writing access by ledger creation) to becoming a validate or full node. In a permissionless DLT, all node users can process

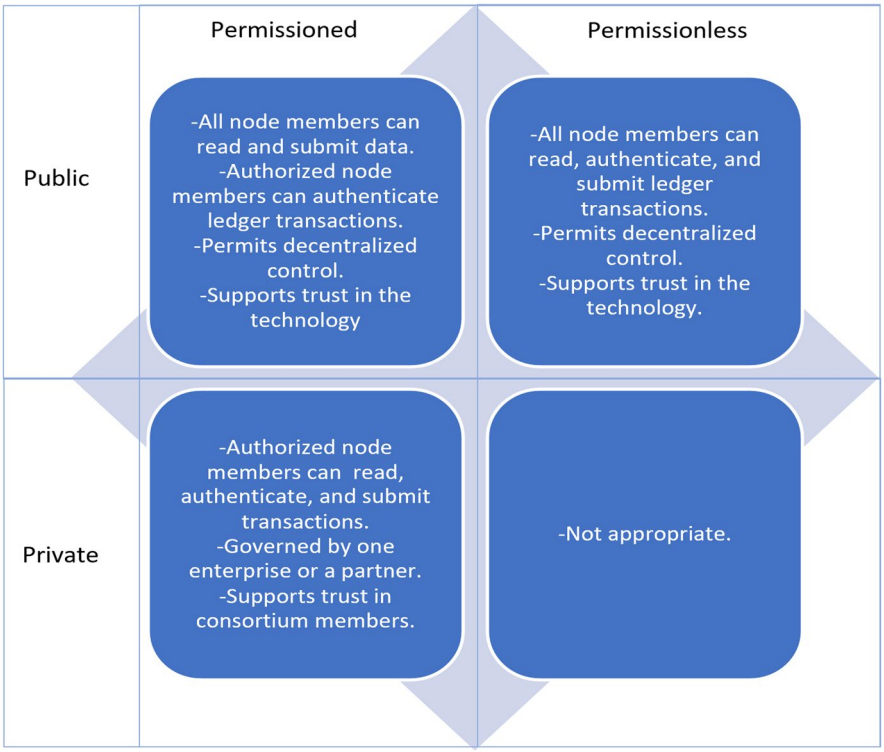

Fig. 9 Categories of governance of DLTs in EE adapted from (Franks, 2020)

ledger transactions occasionally also described to as miners, whereas in a permissioned DLT, this authorization is limited to a selected set of known node users (Pelt et al., 2021). In permissioned DLT platforms, actors such as users, miners, developers, and nodes are less known and achieving consensus over development of the DLT software becomes much harder.

- A public permissionless does not support the reading, writing, and validating of new ledger transactions. As everyone can become a node user. Examples are Ethereum and Bitcoin (Rikken et al., 2019).
- A public permissioned permits reading, but there are limits involved in becoming a validator or a participating node. Thus, it is open for public use, but is managed by the network control who are responsible for validating nodes. This DLT is occasionally open for developing external platforms, for instance, Ripple and Neo (Rikken et al., 2019).
- Private permissioned supports reading but limits nodes in becoming validators. Access is only granted through the network control, DLT owners, or designated validating nodes. Examples are Hyperledger, Corda, R3, and B3i (Rikken et al., 2019). Private and permissioned blockchains supports read and

write permissions which are monitored by central decision makers such as the platform leader or gatekeepers. The gatekeeper grants permissions for users to read or write data based on the user type (Ziolkowski et al., 2020).
- Private permissionless limits reading of ledger data but is open for validating. Mainly, non-existent, though some practitioners claimed to have set up this DLT model (Rikken et al., 2019).

Evidently, public DLTs such as Bitcoin lack a proper governance structure. Nevertheless, developers and community involved in this DLTs can control and make compatible technical changes with the approval of the majority nodes (Llamas Covarrubias & Llamas Covarrubias, 2021). Mostly permissioned protocols are deployed by extended enterprise to govern their DLTs implemented. These enterprises are faced with issues related to trend of growing private powers for selected group of actors (Rikken et al., 2019), which may eventually result to corporate consolidation or plutocracy (Reijers et al., 2018). This is because these DLTs are not governed corresponding to a one-person one-vote rule. But, voting rights are distributed in proportion to the sum of tokens or hashing power each actor has thus resulting to a plutocracy which is rule or governance by the wealthy, which subsequently supports private pursuits against the common good.

Governance Consensus Mechanism for DLT Deployment in Extended Enterprises

DLT have rules that regulate their operations which may change as time goes on. DLT thus require a governance system for managing how these rules evolve. Such rules are termed as consensus mechanism, which is part of the DLT protocol (Ferreira et al., 2019). Consensus mechanism is the method by which node users within the DLT network validate a transaction (DiRose & Mansouri, 2018). The consensus mechanism can be regarded as the internal governing policy of the DLT system (Meijer & Ubacht, 2018). In general, DLT consensus mechanism refers to technical rules and management requirements. The consensus mechanisms specify the ledger size and ledger creation time and are mostly stipulated by the developers' community for better governance of DLTs deployed in extended enterprises. DLT governance consensus mechanisms provide a medium to resolve the issue of opening the DLT system to a different actor while confirming that value is equally provided to all actors (Schmeiss et al., 2019). Consensus mechanisms provide a medium that ensures that a diverse group of actors agrees without any conflict.

DLT governance mechanisms is an important element as supports operational governance of how DLT will work (Llamas Covarrubias & Llamas Covarrubias, 2021). DLT governance consensus mechanisms radically lessen bureaucracy that can occur with the DLT network (John & Pam, 2018). DLTs such as Bitcoin employs a voice consensus mechanism that allocates votes to those stakeholders with more computational power based on consensus mechanisms termed as proof-of-work (Ferreira et al., 2019). Likewise, DLTs such as blockchain employs blocks are constantly joined to a chain mutually by node peers via a mining process. To start this mining process, clients transmit transactions to certain nodes within the peer-to-peer network. Those network nodes are referred to as miners who verify the authenticity of received ledger transactions, create a new block with legitimate transactions to perform a consensus mechanism

towards appending the block. The following chaining of blocks confirms the reliability of the existing DLT and results to an immutable distributed ledger (Fan et al., 2020).

Among the most common consensus mechanisms are the Proof of Work (PoW) which is grounded on the fact that enough computational resources have been used before providing a value for the approval of the network (Lee et al., 2020; Pan et al., 2021). The PoW scheme is utilized in DLTs such as Litecoin, Bitcoin, and other cryptocurrencies. The PoW algorithm has been successful to prevent attack on a DLT network, for example, the Sybil attack (Pan et al., 2021). In the PoW algorithm, participants called miners, go through a competition in which a single winner is permitted to add a new block to the ledger or chain. To be a winner, a miner must resolve a numerical puzzle that needs significant computational power. The likelihood that a miner is first to get a solution that is proportionate to the sum of computational power they assign to the procedure of mining a block. Since winning miners must show that they have obtained the right solution, obtaining the solution is proof or evidence that they have worked on the issue by directing their hash level to it. This algorithm is thus described as proof-of-work (Ferreira et al., 2019). In a situation where there are two differing versions of the blockchain, miners can vote for their ideal version by assigning their computational power to the preferred chains.

Usually, the chain with higher computational power is expected to win and then the failing chain is discarded or rebranded as an independent blockchain (Ferreira et al., 2019). The PoW consensus mechanism is mostly implemented by Bitcoin, although it faces inadequacies in latency and throughput. Moreover, hardware used by miners becomes results to wasteful energy and computation resources. Proof of Stake (PoS) is another consensus mechanism proposed to solve the issue of inefficient resource consumption by employing coin age as an alternative of computing power to the block mining operation. PoS reduces the time to achieve consensus, and it is much friendly to new nodes. PoS is not appropriate for most business environments, since its throughput is still far from what is needed by enterprises (Pan et al., 2021). PoS works on the idea that a user or node has a proper stake in the DLT system meaning that the user has devoted enough in the platform. However, like PoW, PoS cannot prevent the richer nodes from getting richer and poorer nodes from getting poorer trend, which is detrimental for the long-term sustenance of DLT systems (Pan et al., 2021).

Additionally, the Delegated Proof of Stake (DPoS) is a consensus algorithm developed by Daniel Larimer in 2013 to address technical issues such as latency, throughput, and wasted resources. DPoS substantially enhances performance of DLT platforms while preserving a certain level of decentralization (Pan et al., 2021). In DPoS consensus algorithm, super nodes are accountable for daily operations of a DLT infrastructure and are assigned tokens as rewards. These super nodes have a substantial impact on the governance of the DLT platform. Also, there are other consensus mechanisms that can be employed by extended enterprises that adopt DLTs in the literature such as Proof of Importance (PoI), Proof of Elapsed Time (PoET), Federated consensus or federated Byzantine consensus, Proof of Deposit (PoD), Proof of Activity (PoA), Proof of Capacity (PoC), Reputation-based mechanisms, Proof of Storage & Proof of Authority (PoA), and Practical Byzantine Fault Tolerance (PBFT).

Governance Role of Decentralized Autonomous Organizations

One of the initial practical governance of DLT implementations was in April 2016 after Slock.it company created a decentralized investment fund known as the decentralized autonomous organizations (DAOs), which was utilized on the Ethereum blockchain (Lafarre & Van der Elst, 2018; Llamas Covarrubias & Llamas Covarrubias, 2021). The DAO was developed on top of Ethereum as a decentralized, cryptocurrency-based crowd-funded system where shareholders could fund (John & Pam, 2018). The DAO is a set of procedures and rules programmed in smart contract code and deployed autonomously on a DLT network (DiRose & Mansouri, 2018; Reijers et al., 2018). A DAO can imitate the running of more traditional enterprise, like a corporation or institution, without trusting on a legal authority (De Filippi & McMullen, 2018). Individuals that financed the DAO could directly partake into the governance by specifying which projects that they would like to invest in. The DAO was managed via a set of code-based rules referred to as smart contracts which autonomously perform payments when specified conditions are met.

The DAO attracted substantial interest from its initial stages and through crowd funding raised an equivalent of US$150 million value of ether within 28 days (the cryptocurrency native to the Ethereum DLT) from several investors (Reijers et al., 2018), as of May 2016 (John & Pam, 2018). The DAO further aimed to provide a new method for decentralizing crowdfunding and provided the fundamental model upon which potential DAOs could be developed. Regrettably, the DAO test was short-lived due to potential security risks. As after the DAO was online an anonymous attacker started to siphon ether out of the DAO fund by exploiting a security vulnerability within the smart contract controlling the DAO, which allowed the attacker to continually perform withdrawal transactions. A sum of 3.6 million worth of ether of nearly US$55 million (Kim et al., 2018), amounting to about 30% of the overall funds raised, was transferred to another DAO produced by the attacker. The current DAO governance then administered by the smart contracts could not stop or retrieve the stolen funds (Reijers et al., 2018).

Eventually, Ethereum node users voted to deploy “Hard Fork” and revert to the prior state of Ethereum before the hack and all funds were restored, but this divided the entire Ethereum community and of course weakened the trust of the Ethereum foundation which ended the DAO (Kim et al., 2018). Later Ethereum foundation provided an update to the Ethereum software to undo the hack carried out. Although some miners updated the Ethereum software without any objection, other node users argued that Ethereum was not completely immune to centralized governance, raising concerns for Ethereum. Eventually, a few miners remained to use the old platform called Ethereum Classic (ETC) and the new Ethereum DLT, governed by an improved protocol (Reijers et al., 2018), forming a hard fork where two totally different Ethereum infrastructure now exist (Llamas Covarrubias & Llamas Covarrubias, 2021). The lesson learnt from the DAO incident indicated that real governance is needed in DLT infrastructures.

Governance of DLT Challenges in Extended Enterprises

The governance of DLT in extended enterprises is faced with issues such as in the deployment of governance protocols which usually require agreement by majority of node user or stakeholders who may be slow in making decision (Rikken et al., 2019). Also, the governance of permissionless DLTs such as Bitcoin not dominated by any single enterprise is mostly challenging (Rikken et al., 2019), and this sometimes results to disputes regarding the scaling up of the DLT (Bitcoin) between core developers who are responsible to work on the upgrading of the DLT software and miners who participate to mint new tokens and validate the ledger (Allen & Berg, 2020). With regard to governance consensus mechanism, the most frequent issue for consensus mechanisms is the 51% attacks where miner(s) or group of miners in blockchain network and then continuously create the longest chain thereby altering transaction due to changes in or lack of adequate voters.

Another setback is group democracy where decisions are not made based on motivation, but on herd majority voting resulting to voting power balancing. In off-chain governance control, more traditional methods of voting and stakeholder involvement are set up in decision making of policy updates via traditional voting processes. But, as DLT involves technical consultations which could lead to unbalanced power core for other stakeholders but not for core developers (Rikken et al., 2019). The unstoppable implementation of the DLT code and transactions itself is also another issue which at times results to the initiation of fork which occurs when there is a disagreement between user nodes concerning the validity of a transaction, resulting to more than one blockchain being formed in the network (Llamas Covarrubias & Llamas Covarrubias, 2021). In DLT-based systems, users are not known as they are hidden under pseudonyms as such node users can simply generate additional pseudonyms violating the one person one vote policy in DLTs which contradicts a real democratic governance system. Similar challenges of disparity in voting power can be seen in some on and off chain governance methods. This leads to issues of how to address these misuse or unethical use of the DLT platform. Evidently, this opens up transparency challenge for governance of DLT platforms (Rikken et al., 2019).

Besides, norms define governance behavior among core developers of DLT platforms, where these norms may specify that core developers will not try to adversely impact the DLT source code as a moral act of supporting the common good may constrain the governance of the DLT infrastructure. Also, the public nature of DLT software code as open source also hinders some developer's performance to some extent. Thus, the transparency of the DLT software code may constraint core developer's behavior. Most actors and enterprises involved in DLT do not have the skill to read code in real-life scenario as relatively only fewer stakeholders really review the source code even if it is open source (Hofman et al., 2021). Additionally, some core developers may be able to inject code functions into the DLT platform for their personal benefit during the governance of the DLT system, which is reported as previously happened (Hofman et al., 2021).

Furthermore, DLT helps to store data and/or records and safeguard the integrity of these data. But, to effectively determine the governance of a particular DLT platform, it is important to understand what is stored in the DLT system. For example,

issues such as copyright infringement may have to be adhere to, and the data stored in blockchain will need to be checked and this may enforce constraints on the data allowed into the DLT system (Hofman et al., 2021). While DLTs such as blockchain-based platforms are mostly regarded as borderless, there is no stipulated jurisdiction on usage. There may be need for extended enterprises to show compliance with regulations and laws set by the government of the country where the different firms are based. Finally, there may be constraints and laws that are particular to the geography of the country of the extended enterprises; for example, the PoW consensus mechanism might be excessively expensive in some countries with high energy costs or in a hot region where cooling is required for the deployed hardware (Jnr et al., 2018).

Recommendation for Governance of DLT in Extended Enterprises

Digital innovations such as DLTs are increasingly shaping the daily business operations of organizations such as extended enterprises. However, the governance frameworks that are being adopted do not successfully regulate DLT infrastructures (Zwitter & Hazenberg, 2020). Researchers such as Reijers et al. (2018); Llamas Covarrubias and Llamas Covarrubias (2021) advocated for deployment of approaches that provide cost-effective and meaningfully governance for all actors to be involved for greater good and impartiality in DLT systems. Also, uncertainties and risks associated with DLTs should also be considered; for example, security issues, lack of communication and interoperability between different DLT networks, and scalability of the infrastructures should be assessed. From a legal viewpoint, governance of DLT infrastructure as related to data protection and anonymity could led to various concerns. As DLT platforms have been implemented to carry out illegal activities, therefore calls for regulatory standards to discover and prosecute such illicit activities (Llamas Covarrubias & Llamas Covarrubias, 2021).

Likewise, governance of these illegal or illicit utilization of virtual currencies for terrorist financing and money laundering had been a challenge that emerged very at the beginning of DLT adoption resulting to initiation of relevant governance regulation across the world. Using these virtual currencies for transactions has made it impossible to know who sends and who receives payment, for example, in bitcoins, since there are no anti-money-laundering rules when enterprise uses DLTs for transactions (Paech, 2017). Permissionless DLTs such as Bitcoin allow individuals to join the DLT community and authenticate transactions based on pre-defined rules embedded in the software code, with the option for everyone to join or opt-out at will. This negatively impacts the existing administrative and political structures of DLT thus supporting rules of self-governance based on consensus. Therefore, permissionless DLTs may not be suitable for sectors such as extended enterprises as the alliance among the companies can simply turn out to be fragmented and weak. Since there is no stable, dependable governance structures, and with hard forks in DLTs, insecurity and risk among stakeholders may intensify.

Decentralized governance of DLTs do not automatically imply fair and democratic governance, nor do they inevitably provide equal opportunities for all actors. Although in theory no single actor owns or govern the DLT infrastructure, factors

such as stewardship of core developers granting them administrative rights may prevent an open and true democratic DLT community (Atzori, 2017). Respectively, these drawbacks and risks associated with public and permissionless DLT must therefore be carefully evaluated as they possible promote autocratic governance. As stated in the literature (Atzori, 2017), the main challenge of governance of DLT is still linked to how to achieve a balance between individual ethos, innovation, and the wider enterprise and society interest. To this end, the governance of DLT infrastructure may not be decentralized as pointed out by prior study (Llamas Covarrubias & Llamas Covarrubias, 2021), and similarly a genuinely decentralized DLT infrastructure is not supposed to be governed.

But practically, DLTs such as Ethereum and the DAO experience demonstrated the significance of governance in DLT infrastructure. However, private DLTs are mostly applicable with extended enterprises that need to comply with business regulations when making decisions. But, in public DLT infrastructure, it is challenging to effect governance precisely for DLT such as Bitcoin since in real life it eliminates the need for authentication from trusted third-party (Llamas Covarrubias & Llamas Covarrubias, 2021). While the rules and processes involved in using a DLT infrastructure are defined by the core developers and are then adopted by different actors who adhere to these rules. Extended enterprises planning to adopt a DLT-governance on the operations of all partners in the consortium and deploy the DLT infrastructure to accommodate existing Internet governance set by countries or perhaps have a mitigation plan to work around these policies (De Filippi & McMullen, 2018).

Discussions

Inter-organizational collaboration such as extended enterprises are formed to achieve business benefits such as efficiency, transparency, trust, cost savings, and concern of missing out or being disrupted (Zavolokina et al., 2020). Findings from the literature reports on inter-organizational collaborations that adopt DLTs. Thus, DLT is being lauded as a disruptive transformative infrastructure. DLT-based platform are being adopted in extended enterprises to safeguard the integrity, confidentiality, and availability of data in a distributed manner without the presence of a central corporation that governs how these enterprises collaborate in achieving their business operations. However, research related to the governance of DLT in extended enterprises are scarce. The governance processes for creating, altering, and maintaining this technology needs to careful examined. As governance impacts the resilience of any technology (Hofman et al., 2021). Findings from Ferreira et al. (2019) suggest that Nakamoto's initial vision of DLT governance is untenable, because the business such as extended enterprises needs regulation to establish a more legitimate and balance of power among various actors involved in the business process. This raises the issue of how to create and conceptualize governance rules (Zwitter & Hazenberg, 2020).

But little is known about how the challenges extended enterprises face in governing their DLT. Moreover, the decentralized governance of DLT creates difficulties

when enterprises need to change the pre-existing rules as these changes need to be regularly approved and accepted by all members of the extended enterprises (Llamas Covarrubias & Llamas Covarrubias, 2021). As pointed out by Hofman et al. (2021), it may make more sense to adopt a grounded approach for development of governance theory for DLT infrastructure. Therefore, this current study provides conceptualization of governance of DLT in extended enterprises domain partly grounded on IT governance and prior literature (Weill, 2004; Anthony Jr, 2018; Beck et al., 2018). This research develops a governance of DLT framework for extended enterprises that supports stakeholders with understanding and analyzing the governance of DLT infrastructure. The developed framework can be seen as a conceptual framework describing three layers which comprises of DLT governance dimensions, stakeholder/actors, and DLT governance mechanisms.

Prior governance framework developed in the literature are more suitable for blockchain technology governance focused primarily on public permissionless blockchains. Due to this discrepancy of the framework developed in this study is applicable for all categories of governance of DLTs in extended enterprises. Findings from this study provide a governance of DLT framework that enables distributed value creation of business value applicable in a digital ecosystem of collaborating enterprises. As reported by Zavolokina et al. (2020) blockchain ecosystem can provide a platform to support collaboration among enterprise in a blockchain consortium thereby proving individual benefits to all partners. Findings from the article also present governance mechanism control of DLT in extended enterprises, governance actors and categories of DLTs in extended enterprises, and governance consensus mechanism for DLT deployment in extended enterprises. Further findings discuss the governance role of decentralized autonomous organizations, challenges associated with the governance of DLT in extended enterprises and recommendations on how to improve the governance of DLT in extended enterprises.

Additionally, findings from this study reveal that the governance of DLT enables all stakeholders involved in the network to exercise bargaining power over the DLT infrastructure. Also, the governance of DLT infrastructure often involves different groups of stakeholders such as miners, founders, nodes, enterprise users, token holders, and core developers, analogous with prior study (Rikken et al., 2019). Finding from this study is also in line with results from De Filippi et al. (2020), where the authors highlighted that to increase confidence in DLT systems and decrease the risk of opportunism, that governance of DLT systems should be carefully fashioned not only regarding on-chain governance, but off-chain governance as well. The governance of most DLT-based platforms is highly centralized based on-chain governance which is intrinsically plutocratic, controlled by a few individuals or large operators who govern most of the mining resources and/or token assets, while off-chain governance is mostly operated as a technocracy with a limited powerful actor controlling the evolution and development of the DLT infrastructure (De Filippi et al., 2020). Evidence from this study suggest that decentralization inherently influences the political structures of DLT adoption by eliminating a control authority, for instance,how DLTs such as Bitcoin evolves.

Theoretical and Practical Implications

The adoption of DLT in extended enterprises can significantly decrease shareholder voting costs and offers prospects for enhancing business collaboration. Moreover, DLT decrease the business costs for and increase decision-making, making extended enterprises to achieve a lean and efficient corporation. Given the global scale and the fast growth of digital platforms such as DLT, it is relevant for managers to understand the implications of adopting a DLT in extended enterprises. Therefore, the outcomes of this study have both research and practical contributions towards the governance of DLT platforms. Theoretically, this current study provides an understanding on the governance of DLT in extended enterprises which is lacking in the literature. Because the deployment of DLT infrastructure is new, the governance of most DLT infrastructure has been coded to provide trust to a variety of actors and enterprises with different preferences and interests. As such it is crucial to study the challenges of implementing decentralized governance of DLT-based platform (Llamas Covarrubias & Llamas Covarrubias, 2021).

Governance of DLT provides understanding on the power relationships that emerge within the distributed ledger network and helps in allocating responsibilities to key stakeholders such as core developers, miners, etc. in developing applicable governance mechanisms. This study provides the categories involved in the governance of DLTs in extended enterprises to supports decision-making in the different types of DLT infrastructures as seen in Fig. 9. As highlighted in the literature, there is fewer research on the governance of DLT. Therefore, this study provides a better understanding on how the governance of DLT works. This study also present actors or stakeholders involved in the governance of DLT ecosystem in extended enterprises. A framework is developed to support the governance of DLT for extended enterprises which comprises of DLT governance dimensions, stakeholder/actors, and DLT governance mechanisms.

This research provides understanding on available approaches on governance of DLT by designing a theoretical framework that captures the governance consensus mechanisms to guide extended enterprises, regulators, policy makers, and other relevant actors to analyze the governance of DLTs in a structured way. The framework offers opportunities for innovation in governance of DLTs by providing an answer to the call for research on governance of DLT, but also anticipates the challenges and recommendation on governance of DLT in extended enterprises. The framework outlined in this study is designed for businesses seeking to improve their governance of DLT. The framework can be employed by enterprises to serve as a high-level governance tool that provides an agenda for governance within distributed ledger economy and offers additional significant avenues for future governance research by critically examining the challenges present in governance of DLT research. This research presents practical insights into the emergent topic of DLT governance and provides understanding on governance actors and categories of DLTs in extended enterprises serving as an initial roadmap for DLT co-evolution.

Conclusion

DLT infrastructure appears to have the ability to transform extended enterprise processes and their business transaction at both local and international levels. However, DLT adoption is faced with governance challenges. Likewise, extended enterprise lacks an understanding of how to govern DLT-based platforms which in turn informs regulatory policy (Santos & Kostakis, 2018). Furthermore, the governance of DLT is vital for the sustainability of extended enterprise as it enables stakeholders to make decisions on how the DLT eco-system should evolve (van Pelt, 2019). Evidently, there is need for the governance of DLT that comprises of a new set of DLT governance categories, consensus mechanisms, actors, etc. which will characterize the way this disruptive technology evolves. Therefore, grounded 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.

Accordingly, this study provides better understanding on the state of the art of DLT governance in extended enterprises. The findings from this study provide insights into defining actors and the consensus mechanism to be employed to improve the governance of DLT extended enterprises. The findings further highlight the potential for the design of future platform ecosystems that might also use other distributed ledger technologies in the future, irrespective of the contribution of this study. This study has a few limitation which has opened interesting areas for more research. First, there is need to carry out empirical data to verify the developed framework. Primary data can be collected via action research, focus groups, interviews, or surveys. Findings from the primary data can be utilized to preliminary refine the developed framework for governance of DLT. Lastly, more research is to be carried out regarding factors that impact the governance DLT in enterprise context to derive sound variables for conceptualization of a DLT governance model.

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