Blockchain Governance – A Systematic Literature Review

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Abstract. The blockchain technology offers the possibility to decentralize platforms besides a variety of other possibilities. This may even result in the absence of a central authority that defines its governance. Consequently, a special kind of governance can emerge that takes into account the specifics of this technology. While governance in various research areas, such as corporate or IT governance, has been studied for a long time, the study of blockchain governance has only recently begun. Nevertheless, research on blockchain governance is increasing in recent years and an appropriate way to structure it is needed. Hence, the goal of this study is to identify the current state of research on blockchain governance. For this purpose, a systematic literature review is conducted and as a result, 25 studies were identified which address blockchain governance. Moreover, an adapted version of the IT governance cube is introduced, which allowed to structure the concepts of blockchain governance. Furthermore, it allowed to identify research areas that have obtained little attention yet.

Keywords: Blockchain · Governance · Literature Review

1 Introduction

The blockchain technology has received much attention from practitioners and researchers since its first practical implementation by the cryptocurrency Bitcoin [1]. Besides technological features this technology promises decentralization, data integrity, transparency, auditability, and automation as key features [2]. Thereby, especially the possibility of increasing efficiency by avoiding a middleman is a reason for the paid attention [3]. In the case of platforms, this leads to the possibility that a platform operator is no longer needed. While the number of use cases of blockchain technology seems to be unlimited [4], the adoption of this technology in industries still faces many challenges [5]. Additionally to the practical application of the blockchain technology it continues to gain attention from research and the number of related publications is increasing [6]. However, in information systems there is still little research on blockchain [7] and, in particular, research on the governance of blockchain [3, 8]. Due to the technological enabled features of blockchain, governance mechanisms can directly be implemented in the technology [9]. In addition, the need for a central authority, which defines the

M. Papadaki et al. (Eds.): EMCIS 2022, LNBIP 464, pp. 185–197, 2023.
https://doi.org/10.1007/978-3-031-30694-5_14

governance can be avoided [10]. Nevertheless, since this was determined some time has passed and thus, it can be assumed the research on blockchain governance has increased.

Thus, this paper covers the current state of the research on blockchain governance, and addresses the following research questions:

What is the current state of research on blockchain governance?
and
How can the current state of research on blockchain governance be structured?

The remainder of this paper is structured as followed: First, the used methodology of a systematic literature review is described and then, the results are outlined. Afterwards, in the discussion research gaps are identified and a conclusion is given.

2 Methodology

For the structured literature review the guidelines of Kitchenham [11] and Tranfield et al. [12] were applied. According to these guidelines, first of all, the need for a review was identified and a review protocol was developed, which includes the review questions, the literature search and the selection process as well as inclusion and exclusion criteria. In the remainder of this section, the procedure of conducting the review is described, more specifically the process of literature search and selection as well as the data extraction.

2.1 Literature Search

For the search of literature the recommendations of vom Brocke et al. [13] were applied. Thus, the search scope was defined based on the research question. In particular, a sequential process was applied, which should cover most of the relevant literature and thus should be comprehensive. As sources the Association for Information Systems eLibrary and the Web of Science were selected. The first source covers the leading conferences and journals in information systems research and the second one indexes multiple other bibliographic databases such as IEEE Xplore for computer science. For the literature search a keyword search was applied on title, abstract and keywords. The following search string was used:

(Blockchain OR "Distributed Ledger" OR DLT) AND (governance OR govern OR "Decision rights")*

In the first part of this string, the term blockchain, distributed ledger and its abbreviation was used. The second part covers the search term governance. Additionally, a term using an asterisk (govern*) was included to cover also articles using verbs, like governing, etc. Moreover, "decision rights" was added to cover also articles that do not use the term governance explicitly. The latter term was used because it is one of the most important dimensions of IT governance [14].

A pre-test was conducted to check the suitability of the search string. Thereby, the search was conducted and checked, whether the results contain two known articles in each database. This check was passed, so no further changes were made to the search string. The final literature search was conducted in May/June 2022.

2.2 Study Selection

For the selection of studies, the inclusion and exclusion criteria defined in the review protocol were applied. The first in- and exclusion criteria was the focus of the article. It was included, if it focuses on governance of blockchain regardless the concrete field of investigation. On the other hand, it was excluded, if it investigates the blockchain for governance [15] or on the application of blockchain for corporate governance or similar. No methodological restriction was made, so that empirical as well as conceptual articles or reviews were taken into account. In addition, no restrictions in terms of the research outcome were made, so case studies as well as frameworks were taken into account. As a further exclusion criteria the publication language was used and articles in other languages than English were excluded. The publication outlet was used as exclusion criteria and for the assessment of the quality. Thus, not peer-reviewed publications were excluded, which includes publications that are not published in journals or conference proceedings, as well as books or book chapters. An additional exclusion criteria was the date of publication, so only publications since 2008 were considered, which was the publication date of Bitcoin as the first practical implementation of blockchain technology [1].

The applied study selection process, which is outlined in Fig. 1, results in a final dataset of 25 publications. The selection process started with 1788 studies, which were found using the search string in the sources. First, in- and exclusion criteria were applied,

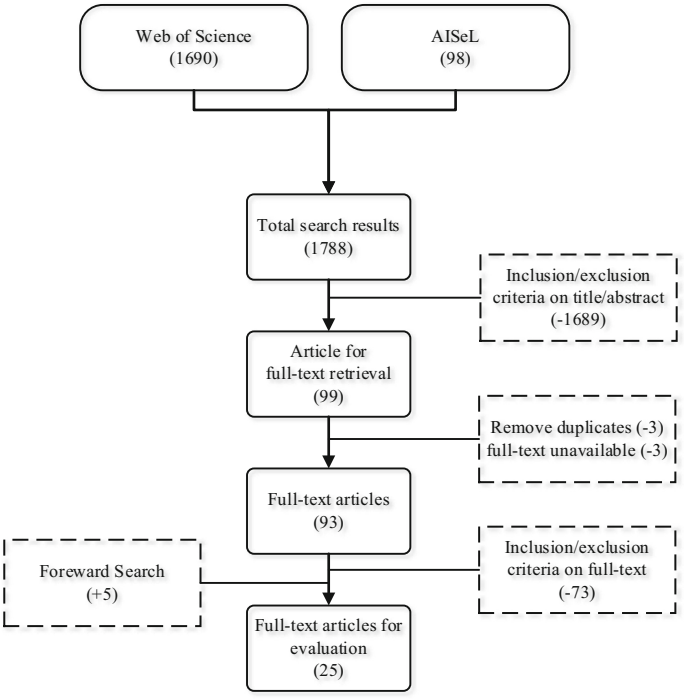

Fig. 1. Study selection process

e.g., publications in other languages than English were excluded as well as studies published as pre-prints. In the same step, the other in- and exclusion criteria based on the content were applied on title and abstract of the publications. This results in a set of articles for which full texts were retrieved. In this step, duplicates were also removed. Afterwards, the in- and exclusion criteria were applied on the full-text. In addition, a forward search was conducted to identify literature, which was not found by the initial keyword search [13]. As the field of study is very recent, no seminal papers were assumed to be found and thus, a backward search would only offer little added value [13].

2.3 Data Extraction

For the data extraction a concept matrix was created while reading the articles, according to Webster & Watson [16]. First, the IT Governance Cube [17] was used as a multidimensional method to synthesize the reviewed literature and to identify research gaps [16, 18]. In the IT Governance Cube [17] governance mechanisms are represented by the dimension *How is it governed?* (e.g., decision rights, architecture, etc.). However, two additional dimensions are necessary to describe this dimension. For instance, the dimension *What is governed?* (e.g., IT-Artifact, stakeholders) refers to the focus of the mechanisms and *Who is governed?* (e.g., ecosystem, firm) refers to its scope, i.e. the unit of analysis.

In this paper, an adapted form of the IT Governance Cube is used because the scope of the governance is defined as blockchain. Thus, the scope now describes on which layer of blockchain the governance takes place. The remaining two dimensions (*How?* and *Who?*) are considered as in the original. The cube of blockchain governance resulting from this is shown in Fig. 2.

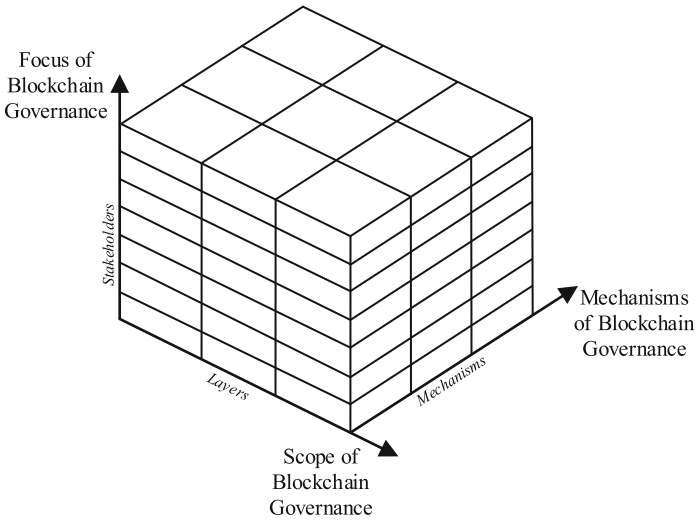

Fig. 2. Blockchain Governance Cube

3 Results

3.1 Focus of Blockchain Governance

For the dimension of focus of blockchain governance, its stakeholders are used as concepts. Thereby, the number of stakeholders involved depends on the specific use case. For example, four groups of stakeholders can be identified for permissionless blockchains [19], eight stakeholders for the Bitcoin blockchain [20] and twelve stakeholders for governance in the blockchain ecosystem [21]. Another study includes also stakeholders from the environment, like governments [22]. Since the reviewed literature refers to different scenarios of blockchain technology, not all stakeholders necessarily appear in it. For example, exchanges are a specific example of a stakeholder in the field of cryptocurrencies or miners in blockchains using Proof-of-Work.

In order to obtain a generic overview about the stakeholders in blockchain governance, a summarized form of the stakeholders for governance in the blockchain ecosystem [21] were used, namely: *nodes*, *developers*, *communities*, *users*, *token holders*, and *organizations*. In this process, not all possible ones were considered, some of them were aggregated, and one was discarded. As *nodes* all kind of nodes (miner nodes, full nodes and masternodes) were grouped together and as *organizations* foundations and consortia or federations were seen. *Token holders* includes token and coin holders, stakers, delegates and arbiters. The stakeholders *developers*, *communities* and *users* were taken over one to one and "Projects and DApps as stakeholders" were discarded. Additional stakeholders like technical suppliers or special community members, e.g., curators, are listed as *others*.

Nevertheless, a clear distinction between the stakeholders is not always possible and depends also on the analyzed case. Thus, overlapping stakeholders can occur, which belong to multiple categories [22]. For example, developers and users are often part of the community or token holders are also users, which might be caused by a necessary ownership of tokens for using the platform. Another example can be a member of the core developer team, who also holds tokens and is active in the community.

An overview of the stakeholders in the focus of blockchain governance in the reviewed literature is shown in Table 1.

Table 1. Focus of blockchain governance.

Stakeholder	Sources
Nodes	[3, 8–10, 19, 21, 23–35]
Developers	[3, 8–10, 19, 21–24, 26–38]
Communities	[3, 9, 10, 19, 21–28, 30–35, 37–39]
Users	[8–10, 19, 21–23, 25–30, 32–39]
Token holders	[3, 8, 21–23, 25–27, 31, 34–39]
Organisations	[3, 9, 19, 21, 23, 30, 31, 34–36, 40]
Others	[3, 9, 21–24, 26, 28, 34, 40]

3.2 Scope of Blockchain Governance

The scope of blockchain governance describes on which layer the governance takes place. For the purpose of this study, two classifications are merged. One of these differentiates in on-chain and off-chain governance and the other one describes where exactly the governance takes place on-chain. Figure 3 gives an overview about the used scope of blockchain governance. Beside the scope it also shows some of the stakeholders, which occur in off-chain governance.

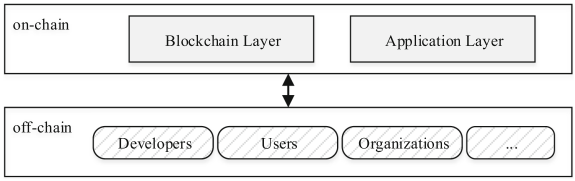

Fig. 3. Scope of Blockchain Governance

In this regard, on-chain governance describes rules and processes, which are directly implemented as code in a blockchain-based system, in which interactions between the participants take place. Hence, the technology is enforcing the governance. In contrast, off-chain governance refers to all other governance, which is not included in on-chain governance and which is not directly implemented as code. For instance, this includes governance of developers and communities belonging to the system. Furthermore, in contrast to on-chain governance, it is not automatically enforced by the system [31, 41]. The rules and processes of blockchain governance can be multi-layered, so that one layer has influence on another layer. As the case of "The DAO" and the resulting hard fork has shown, off-chain governance has an impact on on-chain governance [41]. With on-chain governance a further subdivision can be made on the basis of the blockchain stack. These include the blockchain layer, which consists of blockchain networks like Ethereum, and the application layer, which includes dApps and DAOs [7, 41]. There are other descriptions of the technological blockchain stake besides this one (see e.g., 42, 43), but due to their focus they are less suitable for the current study. The same applies to partitions of off-chain governance in community and development [3], which, however, does not take into account all of the previously identified stakeholders in the scope of blockchain governance.

In Table 2 the considered layers of the reviewed literature are shown. In most cases one of the two on-chain layer is combined with the off-chain layer, followed by a combination of both on-chain layers with the off-chain layer.

The inclusion of on- and off-chain layer often depends on the analyzed field, e.g., a voting process of a DAO is on the application layer on-chain due to its technological implementation, but also covers participants in the process, which were off-chain, e.g., users or token holders.

In addition to this distinction, the mutual influence of the two layers should be considered, as they are partly based on each other and influence each other. This can be described as reciprocal governance. In this concept blockchain governance includes governance by

Table 2. Scope of blockchain governance.

Layer	Sources
On-chain blockchain layer	[3, 8–10, 19, 21–24, 26–29, 31, 33, 34, 40]
On-chain application layer	[3, 8, 10, 19, 21, 25–28, 30, 32, 34–39]
Off-chain	All

blockchain, e.g., consensus, and governance of blockchain, e.g., decision making processes. The governance of blockchain influences the governance by blockchain through technological changes and vice versa by the application of the implemented governance [28]. An example for influences between off-chain and the blockchain layer is the specific governance mechanism of Ethereum Improvement Proposal (EIP) or Bitcoin Improvement Proposal (BIP). In this mechanism any community member can submit a change proposal for the underlying code of the blockchain [44]. Then, the community and the core developer team review the proposal and if necessary, improve it. At the final stage, the BIP and EIP differs. On EIP, the core developer team decides on including it in a new release of the protocol, based on their assessment. The same applies to BIPs, but with these mining nodes vote on the change by applying the update [24, 45]. Hence, the implementation of these changes on the on-chain layer has effects on the users, which can be located off-chain.

In case of the application layer, nearly the same process occurs in DAO, but it differs in terms of participants and in terms of its effects. A change proposal can be created by members of it and is discussed in the community. Then, a voting process by smart contracts in which token holders can participate takes place and afterwards, the proposed smart contracts will be deployed. In addition to voting on operational decisions, these may also include strategic decisions, such as system upgrades [38], which can lead to updates of the implemented rules [39]. Hence, the voting process for updates can also be updated, so the on-chain and off-chain layers affect each other [25].

3.3 Mechanisms of Blockchain Governance

The reviewed literature examines mechanisms of blockchain governance from various perspectives. At this point, the focus is on the governance mechanisms decision rights and incentives, as they are specific to blockchain governance and takes place on-chain and off-chain. Moreover, mechanisms of coordination and control are considered as blockchain specific mechanisms. Their coverage in the literature reviewed is shown in Table 3. Other governance mechanisms, which are also crucial for blockchain-based platforms, are for example accessibility or perceived trust [30, 34]. These are not considered here due to the reason they are not specific blockchain governance mechanisms and are mainly adapted from the research on platform governance.

The mechanisms of decision rights were structured based on the scope of blockchain governance, more specifically by the level on which the decisions takes place and on which level they have impact. Additionally, the stakeholders, who are involved into the decision process and have the power to decide, were taken into account.

Table 3. Mechanisms of blockchain governance.

Mechanism	Sources
Decision rights	[3, 8, 10, 21, 23–26, 28, 33, 36, 38, 39, 44, 45]
Incentives	[3, 8, 19, 26, 30, 32, 34–38]
Coordination & control	[32, 35, 40]

The consensus mechanisms are a special form of decision rights in blockchains. In this procedure mining nodes decide which copy of the transactional database is used by consensus between the participating nodes [10]. In addition, nodes do also have the final decision rights about adoption of software changes and forking the system [21]. Thus, the direct decision takes place on-chain and has impact on this level. The stakeholders directly involved in this process are nodes. In case of Proof-of-Stake, the same holds true but instead of nodes the token holders are involved [23]. Examples of changes to the software can be the BIP or the EIP described above. Another mechanism taking place on the same layer is forking, by which conflicts about decisions can be solved [8, 21]. More precisely, this mechanism can occur, if existing other procedures cannot lead to a decision, e.g., in the case of the DAO attack [31].

In case of the adoption of software changes or forking, the decision itself occurs on-chain, but the process thereof is located off-chain. For off-chain decision process the influence of individual community members on the community was shown exemplarity by BIPs. Thereby, single influencers, which were part of the community, use different tactics to enact their desired rules, which are to be technological implemented [33].

A special form of decision rights is voting, which occurs using smart contracts on the application layer on-chain. Although the decision on software changes or the state can also be seen as a kind of voting process [23, 24], the term voting for voting processes based on smart contract. In case of DAOs, holders of governance tokens are able to decide on proposals for the platform to change its processes [39]. In some cases it is also possible that users without governance tokens can submit proposals [21]. The most common voting system is based on the amount of owned tokens [25, 38], but also other voting models exist, like one vote per individual [21] or liquid democracy [25]. Regardless of the low participation in voting within DAOs [39], strategic voting tasks can improve its operational performance, whereas operational voting tasks can worsen it [38]. Moreover, by the transfer of decision rights from the former platform owners to token holders decentralization can be archived [36].

The next mechanism of blockchain governance described in the literature are incentives. It describes, who is awarded for what and how. The awarded stakeholders include nodes, developers, users and token holders [8]. Thus, the mechanism of incentives can occur on all layers of blockchain governance. According to their type incentives can be divided into monetary incentives, like mining fees for consensus, or non-monetary, like reputation [8, 35]. Whereas on the blockchain layer mining fees or similar monetary incentives occur, on the application layer both types of incentives exist [35]. Moreover, participation in decision rights can also be seen as an incentive [35, 38], as well as participation in the further development of a platform [8] or its usage [8, 36]. Mainly

through this mechanism stakeholders should act in a desired behavior [8]. For example it can be used to motivate them to participate, to facilitate a specific output [32], or to act honestly [37]. Some of the incentive mechanisms like the consensus on a blockchain as the technical foundation of a blockchain are necessary and thus can be seen as crucial [8]. Besides the positive mechanism of incentives, which are awarded for desirable behavior, sanctions can be seen disincentives, which punish undesired behavior. By this, nodes can be suspended from the mining process for malicious behavior [21, 35] or token holders can be punished by burning their tokens [34].

The governance mechanisms of coordination and control describe who is how coordinated or controlled and by whom. On the technical layer, nodes are self-coordinated and -controlled by the used technical protocol. In case of an underlying blockchain technology, like Ethereum, changes in this mechanism depend on it. If an own blockchain is used, proposals can be used to alter the coordination mechanisms. Experienced users, developers or the organization evaluate these and decide on them. The developers themselves are in most cases coordinated and controlled by an organization, e.g., by off-chain contracts. Although an blockchain-based form may be desired, it is not yet implemented [35]. Beside these coordination and control mechanisms, also incentives, sanctions and decision rights, which were mentioned above, can serve as mechanisms for it. Moreover, smart contracts can serve as control mechanisms, because rules are implemented and enforced automatically [32]. The mechanisms of coordination and control were also analyzed in the field of enterprise blockchains. Thereby, the focus is on intra-organizational coordination and control. For control mechanisms, the allocation of decision rights is a main issue between organizations [40].

4 Discussion

The objective of this study is to review the current state of research of blockchain governance and to propose a way of structuring it. Therefore, a structured literature review was conducted, by which 25 studies on blockchain governance have been identified for analysis. For structuring the research on blockchain governance, an adapted form of the IT governance cube [17] was used, which offers the possibility to synthesize existing research and to identify research gaps [16, 18]. In the following the results of the literature review along the presented dimensions of blockchain governance are being discussed.

In the dimension of focus of blockchain governance several classifications for stakeholders of blockchain governance have been identified [19–22]. They differ in their range, e.g., they include environmental stakeholders, as well as in their levels of detail, e.g., they distinguish between types of nodes. To structure the identified literature, a smaller scope without environmental stakeholders was used. Furthermore, an adjusted level of detail was used to be as general as possible and, at the same time, as detailed as possible. This made it possible to obtain an overview of the considered stakeholders in the literature. Nevertheless, the classification of stakeholders is not mutually exclusive, since one actor can take on different stakeholder roles, e.g., token holder and developer. It can be seen that most of the literature investigate stakeholders involved in the governance mechanisms, like token holders, developers, communities and nodes. In contrast,

less attention paid to stakeholders, like users, who may be only affected by blockchain governance. Consequently, a lack of deep understanding of the stakeholders can be seen [22].

In contrast to the original IT governance cube, the scope of blockchain governance describes on which layer the governance is located. For this purpose, first the classification of on- and off-chain governance [31, 41] was used. Further classifications of off-chain governance, like community and developers [3], were not used. They do not cover all stakeholders from the focus of blockchain governance that can be located off-chain, like users or organizations. To take into account the different concepts of blockchain, which are used in the literature, the on-chain layer was divided into application and blockchain. By using this classification it was possible to determine that the majority of the reviewed literature examined one of the two on-chain layers in combination with the off-chain layer. Only a few studies cover both of the on-chain layers. Moreover, the mutual influence of on- and off-chain layers could be presented by this classification.

The mechanisms of blockchain governance were narrowed down to mechanisms, which are blockchain specific and are located on-chain at least partly. These were decision rights and incentives as well as coordination and control mechanisms.

For the decision rights the processes of finally making the decision takes place on-chain, regardless on which layer exactly. Thus, stakeholders like nodes or token holders (e.g., [23, 24]) are involved. Nevertheless, other stakeholders are involved in the upstream decision-making process, which can takes place on the off-chain layer. Examples for this are the influence of individuals on the decision-making process [33] or in the decision-making process by developers [35].

In the case of incentives, it was possible to distinguish between who receives which incentives from whom and what type of incentives these are. It was possible to observe that incentives can occur on all layers of blockchain governance and that sometimes they have only an indirect relation to the on-chain layer. The participation in the usage of a blockchain-based platform as an incentive is an example for this [8, 36]. In addition to incentives, which award a desired behavior it is also possible to punish undesired behaviors by disincentives, so called sanctions. However, these ones are only marginally considered in terms of focus and scope.

The governance mechanisms of control is closely related to decision rights and incentives. Both can be used as control mechanisms, to control the behavior of stakeholders by motivating them to behave in a desired way. The emerging coordination mechanisms can be differentiated by the on- and off-chain. Thereby, coordination mechanisms affecting stakeholders like nodes are implemented in the code, are self-executing and are located on-chain. In contrast, the coordination of other stakeholders, like developers or communities, are not implemented in the code and are thus located off-chain.

5 Conclusion and Outlook

This study provides an overview of the current state of research on blockchain governance. For this purpose, a structured literature review was conducted. As a result of the literature search and study selection 25 studies have been identified that address blockchain governance. An adapted form of the IT governance cube with the dimensions scope, focus and mechanisms was used to structure the identified literature. This

allows to provide an overview of the identified literature and to categorize its concepts. Future research can use this as a tool to categorize research on blockchain governance and thus as a structure to identify research gaps. Moreover, in this study it was possible to identify research areas that had received little attention so far and thus should be investigated more closely by future research. For the focus of blockchain governance these are stakeholders, who do not directly participate in it, but are only affected by it. For example, a user may be affected by governance decisions of voting processes, in which he cannot participate. Moreover, the appearance of stakeholders in multiple roles has been underrepresented so far, e.g., developers who also hold tokens. For the scope of blockchain governance the mutual influence between on- and off-chain layers should be studied in more detail, in particular the influence of off-chain decisions on the on-chain decision-making process and vice versa. In the field of governance mechanisms, it was identified that the upstream decision-making process should be examined more closely, which is related to the mutual influence between layers. Moreover, the focus and scope of disincentives or sanctions should be examined. To overcome these shortcomings, future research is suggested to include qualitative methods such as case studies, which will allow investigating them in detail.

A natural limitation of this study finds its cause in the used search term and in the used databases by which the search result was limited. In addition, subjective interpretations may have affected the selection of literature and the assignment of concepts. In addition to the methodical limitations, narrowing down the governance mechanisms to blockchain specific ones is a limitation on its own, which necessities further research. To overcome this limitation and to extend this study also other governance mechanisms should be taken into account, e.g., mechanisms of platform governance.

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