Examining Gentle Rivalry: Decision-Making in Blockchain Systems

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Abstract

The blockchain comes with the promise of being a disruptive technology with the potential for novel ways of interaction in a wide range of applications. Although scholarly interest in the technology is growing, a broad analysis of blockchain applications from a governance perspective lacks to date. This research pays special attention to the governance of blockchain systems and illustrates core governance decisions on 15 blockchain systems from four application domains. Based on academic literature, semi-structured interviews with representatives from those companies, and content analysis of grey literature, different blockchain governance decisions have been derived and their enactment described. The identification of them enriches the scarce body of knowledge on blockchain systems with a better understanding of how key governance decisions are enacted in practice.

1. Introduction

In recent years, the blockchain technology emerged from a provider of cryptocurrencies to an alternative fashion to maintain and share data in a collaborative manner. All over the globe, organizations of all sorts form consortia to explore the merits of this technology. Those merits vary from product innovation or optimization of inter-organizational business processes by replacing third-party-authentication with the algorithmic that blockchain natively provide.

Despite all the enthusiasm, how those efforts are governed – also beyond who is formally in charge - remains an open question. The history of research on open as well as inter-organizational collaboration is long; despite being fundamentally different, collaboration within both has not always been fruitful, due to mistrust, missing say, or own interests [1], [2] – the governance of inter-organizational collaboration is of utmost importance as it safeguards involved party's interests [3]. Our research sheds light on how blockchain systems are governed, seeing governance as decision rights placement and enactment. We thereby derive six core decisions and illustrates their enactment on 15 cases complemented with 18 semi-structured expert interviews with representatives from those cases.

Little is known about what and how key decisions are made and enforced in blockchain systems [3]. Decision-making and enactment can be conducted in several ways as it can be seen in free-and-open-source (FOSS) projects [4] or business networks [5]; even in those, collaboration may vary greatly. There is a plethora of governance frameworks in IT, in the corporate realm, public administration, and many more; a governance framework for blockchain systems examining the generic roles, responsibilities, decision rights, or incentives of actors in a blockchain system is yet to be defined. This gap in literature is motivating, not least because the number of blockchain projects is steadily increasing.

Hence, this research answers the incumbent call for research on how blockchain systems are governed [6], [7]; not only to improve their well-functioning from an organizational perspective [8], but also to anticipate future inhibitors which may arise and the changes they bring to various domains [9]. Therefore, this research answers the following research questions:

RQ1: What are major decisions about blockchain systems?
RQ2: How are those key decisions enacted in practice?

Section 2 provides an introduction to the research topic and introduces the reader to the field of governance in general as well as from a blockchain perspective. Next, section 3 details this research's underlying methodology. Section 4 presents the results of the analysis, with a narrow focus on blockchain decisions and how they are enacted. In section 5, the results are discussed against the background of the works identified in section 2. Section 6 concludes by giving an outlook for future research venues.

URI: https://hdl.handle.net/10125/59891
ISBN: 978-0-9981331-2-6

2. Related Work

2.1 Blockchain Systems

As this paper centers on governance, a technical explanation of how blockchains work is not considered here. However, to grasp the main differences in decision-making processes that blockchain brings about, it is helpful to use existing classifications of blockchain systems and to outline their main characteristics. A blockchain system is hereby defined as the underlying technology (blockchain) and its organizational embedment (community surrounding the blockchain and its utilization). Following the notion of Peters and Panayi [10], a classification of blockchain systems can be seen along the access to transactions (public or private) and transaction validation rights (permissioned or permissionless).

Table 1. Classification of Blockchain Types, adapted from Peters and Panayi [10]

Access to Transactions		Access to Transaction Validation	
		Permissioned	**Permissionless**
	Public	All nodes can read/submit transactions;authorized nodes validate transactions.	All nodes can read, submit, and validate transactions.
	Private	Only authorized nodes can read, submit, and validate transactions.	N/A

Blockchains proved to overcome the double-spending problem and, hence, bring rivalry to digital settings [8]. With this characteristic of native authentication of rightfulness [8], blockchain systems became increasingly interesting in domains which use to rely on third parties to provide authentication, such as banks or notaries; a blockchain system, hence, can provide trustworthy data: if entered data is correct, the ledger can guarantee its immutability, at least in prospect. This reliability is fostered through the blockchain's characteristics of decentralization (no central entity), persistency (transactions cannot be deleted), auditability (traceability of events), and anonymity (key pairs) [11], [12]; the latter may vary depending on the utilized type of blockchain systems.

2.2 Governance from different perspectives

The meaning of governance is tailored to its application domain, with the most prominent being political [13], IT [14], social sciences [15], or industrial [16] governance. At its core, governance describes how responsibilities and powers are aligned among actors, who decides, how the decision-making process is conducted, and how decision-makers are held accountable. According to well-known works from social sciences, governance structures can roughly be classified into markets, hierarchies, and networks [16], [17]. Decision-making rights and their enactment are thereby placed either on individual actors' (markets, free choice), formal organization (hierarchy, authority), or on consortia's level (networks, consensus). To understand the nature of how decision-rights are allocated and enacted in blockchain systems, the overall process of alignment, translation, and deployment of business / community goals into technological outcomes has to be understood. Hence, we consider the broader notion of the governance of IT systems; this lens is helpful to understand the interplay between the emergence of requirements towards a technology and the factors that assure its successful implementation [18]. Weill [14] defined five core decisions to be made: IT principles (how is IT used in business), IT architecture (technical choices), IT infrastructure strategies (strategies for base foundation), business application needs (specifying business needs for development), and IT investment and prioritization (decisions on how project approval is conducted). The efficiency gains through decision placement has been found to amount to more than 40% [19].

2.3 Governance of Blockchains Systems

Because of its decentralized nature, the governance of blockchain systems may differ from known governance archetypes, such as markets or hierarchies. Public and permissionless blockchain systems, such as Bitcoin or Ethereum, received increasing attention of researchers [7], [20]–[23]; their governance can be characterized as tribal [8]. In tribes, actors tend to organize in loosely defined groups which are always on the brink of creating new tribes (forks), as long as long as the overall organization benefits from a critical mass to maintain the system and stabilize its value (e.g., its underlying currency). The architects of those systems, for the initial design as well as later enhancements, are typically core developers (e.g., [24]). Open source principles, which are commonly adopted here and allow users to propose changes to the system as they see fit, can be supported by developers, but they need to find the agreement of other core actors, especially miners and token-owners. Having no entity formally in charge [21], those decision-making cycles have proven painfully complicated and ineffective, leading to governance crises posing constant threats to the community [9]. While the decision-making is formally placed on the sides of miners', users' and developer's, it has to be mentioned, that prominent figures (e.g., Vitalik Buterin) hold major influence on public opinions, and hence, on system architecture development; differently from other information systems, however, the developers' or public opinion leaders' influence can be counterbalanced by either miners' or users' [3], [21].

The prospect of digital scarcity (hence uniqueness) of data attracted interests also from domains other than cryptocurrencies, contributing to the increasing popularity of permissioned blockchain systems led by consortia (e.g., Corda [25]). Inter-organizational collaboration requires a consensus among collaborating parties, which proved to be a challenging task [1], [26], inhibited by inter alia lack of trust amongst collaborators, own interest, or inter-firm rivalry. So, governance in inter-organizational settings provides an agreed upon playbook to ease those issues and foster collaboration [1]–[3], [27].

By its very nature, permissioned blockchains vary from permissionless ones in the restriction of either validation or access rights or both [10]. Agreement upon data validity is thereby dependent on both well-allocated write rights to write data (content) to the ledger and an appropriate consensus algorithm to preserve its state. Further, the notion of smart contracts brings a form of algorithmic governance, providing an agreed upon, deterministic sequence of events based on input criteria [28], [29]. Same as smart contracts, and other information systems, the overall blockchain system is subject to change over time [30] and thus requires a corresponding process.

Drawn from the previous arguments, it can be seen that forms of organizing, hence the decision-making process, in and around blockchain systems vary and clear responsibilities are hard to be assigned. It remains unexplored, which decisions are deemed central to blockchain systems and which actors or organizations actually sit in the driver's seat, if there is one at all, and steer the development of blockchain systems. This demands exploration in the field.

3. Methodology

In the form of an exploratory study [31], [32], we assured a wide coverage of information and (1) derived codings based on practitioner's view and scientific literature (literature review, grey literature review), (2) found a suitable sample to apply those codings (Interviews, Code Review), and (3) utilized internal as well as external feedback for sense-making (data analysis and evaluation and refinement). We detail these steps in the following.

Step 1: Literature review. This research began with an in-depth literature review following the methodology proposed by vom Brocke et al. [33]. The scope of the search has been set on governance and how it translates to the blockchain realm in order to find core decisions blockchain projects have to conduct (RQ1). We utilized those as a lens to study our case sample in a subsequent step. To assure a consistent search, we first specified what is commonly understood as governance, and which parts we specifically address. In a next step, we searched for literature on the main global repositories ACM, Scopus, and Google Scholar, utilizing the following search terms (and their variations): 'Blockchain governance', 'inter-organizational governance', 'shared governance', 'blockchain decision-making', 'decentralized governance'. To assure an overview as comprehensive as possible on this topic, and to include also practitioners' views on blockchain governance, a number of further information sources were used as described in step 3. All sources combined served as our basis for our synthesis.

Step 2: Interviews. To study the enactment of decisions in practice (RQ2), we searched for mature blockchain systems as our empirical field, which proved difficult because blockchain's recent emergence has not allowed for many well-established systems. From a longlist of 121 companies, which we identified through Coindesk, Crunchbase (both widely considered the most authoritative specialized news source), and LinkedIn, we selected 49 as we saw the best prospect in them concerning their organizational maturity. Then we identified and invited representatives from those cases for interviews. 18 of them accepted our invitation (table 2). To assure the right framing of the interview setting and the right person to speak to, we prepared and sent sample interview questions beforehand. The interviews followed the notion of semi-structured expert interviews [34], mostly conducted via Skype, and were recorded and transcribed for coding. In some cases, two representatives from the same company holding different positions were interviewed. This allowed to gain different perspectives on the same case.

Step 3: Grey literature review. As a complementary source of information to expert interviews, whitepapers and documents of all sorts regarding those cases were helpful to understand the features of each blockchain system and its high-level architecture. The organization's website and press articles (e.g., Coinbase) were also considered useful sources of information, as they reflected opinions on the topic and addressed issues by those companies.

Step 4: Source code and smart contracts. We further reviewed the source code of those company's systems we interviewed, if publicly available.

Table 2. Interview Sample

Date	Interview No.	Case No.	Domain	Location	Maturity	Role of Interviewee
29.05.17	I1	1	Land Registry	Ghana	PoC	CEO
31.05.17	I2	2	Land Registry	Honduras	PoC	Project Manager
02.06.17	I3	3	Supply Chain	USA	Operational	IT Employee
20.10.17	I4	4	Cryptocurrency	Globally	Operational	Team Coach
25.10.17	I5	5	Land Registry	Estonia/Sweden	Completed PoC	Project Lead
26.10.17	I6	6	Cryptocurrency	Globally	Operational	Project Lead
30.10.17	I7	7	Supply chain	Switzerland	Conceptual	Board Member
31.10.17	I8	8	Cryptocurrency	Globally	Conceptual	Project Lead
01.11.17	I9	9	Supply chain	China	Conceptual	CEO and Founder
03.11.17	I10	10	IPR	Globally	Completed PoC	Associate Director
07.11.17	I11	11	Supply chain	Belgium	PoC	Co-founder and CPO
10.11.17	I12	10	IPR	Globally	Conceptual	Application Engineer
15.11.17	I13	12	Cryptocurrency	Switzerland	Operational	IT Director
17.11.17	I14	11	Supply Chain	Belgium	Completed PoC	Business Developer
17.11.17	I15	13	IPR	Globally	Operational	Application Director
20.11.17	I16	14	Land Registry	Georgia	PoC	Security Managers
23.11.17	I17	14	Land Registry	Georgia	Conceptual	Project Manager
23.03.18	I18	15	Cryptocurrency	Switzerland	Completed PoC	CEO

The purpose of this step has been to see in how far algorithmic governance (smart contracts) is utilized to support governance functions and how they are encoded. Further, this step increases the internal validity of information obtained during interviews as it confirms the interviewee's reasoning.

Step 5: Data Analysis. As a first step of sense-making, we coded obtained scientific and grey literature, blockchain source code, and interview transcriptions. The objective of using multiple sources of data was to compare and cross-check the data collected through interviews from people with different perspectives. Each interview was transcribed and coded. Coding dimensions were derived by literature and centered around: 1) The involved actors and their responsibilities, 2) the type of blockchain in use, 3) chosen consensus mechanism, 4) decisions taken by the actors 5), the current phase of the project, and 6) the expected advantages of using blockchain technology. The results of this analysis concerned the blockchain governance decisions as well as their enactment in practice, as described in results.

Step 6: Evaluation and Refinement. Once our initial results were clarified, we sought for feedback. We thereby made our results available to co-researcher as well as practitioners working in the blockchain realm. This phase has been conducted in an iterative fashion until theoretical saturation was achieved. The experts' feedback was then considered appropriately in the further design of this research.

4. Results

As for RQ1, a review of academic literature, grey literature, interviews, and code analysis revealed six core blockchain governance decisions (see table 3). We describe each decision in 4.1 and relate them first to literature and second to our cases. Section 4.2 then details the fashion in which they are enacted, targeting RQ2.

4.1 Blockchain Governance Decisions

Demand Management (DM). Demand Management regards who decides on how to enhance the blockchain system when novel requirements emerge. For example, if there are changes necessary to the API or business architecture, who is involved and decides on the adjustment of those (single actors vs. consensus among many) and how the decision would be made (ad-hoc vs. planned); actors can be internal (e.g. users) or external actors (standard-setting bodies, regulators).

Related to Demand Management, Walport [3] argues that in order to avoid degradation of the technology and to serve a long lifetime, the blockchain should be continuously updated and enhanced. Okada et al. [35] emphasized the importance of this decision referring to organizational decision-making and interoperability. Decisions on standards may also be made here, easing challenges in interoperability as blockchains vary in codebase and infrastructure; standards certainly help the organization to select the most appropriate blockchain for their businesses [36], [37]. Similarly to Weill and Ross [19], this decision refers to "Business Application Needs" and "IT Investment and Prioritization"; in blockchain systems, however, the fashion in which those requirements are decided upon (community vs. hierarchical decision) varies.

Data Authenticity (DA). Data Authenticity regards two aspects: Data input as well as its preservation.

Table 3. Blockchain Decisions and Exemplary Quotes

Decision	Description	Exemplary quotes from cases
Demand Management	who decides and how decisions are enacted when novel business requirements emerge.	"Master node selects those projects, (…), we are using the mining rewards to fund these projects, basically, 45% of the mining rewards goes to miners and 45% to the master nodes, and they are rewarded for providing this hardware to the network. So, in our network, there are miners and master nodes who are receiving the rewards and 10% goes to our self-funding system treasure." **(I6)**
		"Right now, we are about to upgrade our network, and this is being done through a **discussion** between just a small handful of developers, it's a small network, and it's fairly easy to achieve **verbal consensus** for a change." **(I5)**
		"The (…) **government** is fully controlling the rules of the blockchain that can be audited by the third parties, so I think the process will look as following: They will propose something they want to add." **(I14)**
		"We are talking to a number of parties to check whether in the future we can get a standardized object model for instance. So, we contacted **standard-setting organizations**, (…) but it will take years before we really have a standard implementation." **(I8)**
Data Authenticity	who writes data to the ledger and who validates transactions and hence is responsible for data quality in the ledger.	"We use **Proof-of-stake**, so every party that has a node has a voting power (…). Every individual node can register the data." **(I6)**
		"In a private blockchain, we don't have miners but instead we have a number of entities 4 to 15 may be who sign what transactions are allowing to the blockchain so they have a **notary function** and they don't necessarily need to be one of the parties to add the smart contract or any transactions." **(I2)**
		"When the artist makes the claims, people cast their opinion. Based on **majority votes** it is declared whether it is valid." **(I15)**
		"All the miners have to agree. When they agree that the block is solved and it goes in the ledger (...)." **(I1, in line with I8)**
System Architecture Development	who decides over requirements and functionalities of the blockchain system.	"Since it's an AG, the **shareholders** have the usual rights. The **token** holders can vote on milestones, which will unlock further (…) tokens. It was our initiative to reform the traditional system with the blockchain solution, and we also ensured the feasibility, requirements, features of the solution." **(I4)**
		If there is a bug fix or something like that *(our partner)* will say we would like to push this out to all 8 or 9 nodes, (*which causes*) a **single point of failure**. Instead: Each node pulls (*the code*) and they should check because every node is responsible for what they do and if we can push out." **(I5)**
		"(…) so, we will make the bug fixes and the decision to deploy and to determine the priority the **community will take it**." **(I8)**
		"We will have some kind of start-up groups dependent on the underlying products. I think that is practical because if we have ten banks who form the core developers. Everybody got a **different opinion** so we will end up having troubles." **(I12)**
Membership	granting or denying requests to partake in the network.	"The **port authority** will take this role. It won't be the port authority on its own. They will form a (…) **private company** such that (it) can do governance on the blockchain, that will allow people to join." **(I11)**
		"Right now, the (state agency) is **authorizing** to join this network, I think after some time back, they will announce that everything is working good, and they will ask some other third party to decide this, but I don't know when it will happen." **(I17)**
Ownership Disputes	resolving a conflict when multiple users claim for the same asset (e.g. land ownership document or intellectual artwork).	"They have to go to **real world copyright law**. They will use for example such claims as additional evidence in resolving the disputes and this means you need to the system cannot resolve the conflict by itself it has to assign it to the human layer legal system and all of that. This claim is the additional evidence that something happened that specific domain." **(I15)**
		"The **court system** with its own private key is allowed to overwrite. Whatever so in a system of not using on chain currency it's more equation of making sure that everything gets notarized properly. So, if the court will revert something, they can't edit the blockchain what was before and what they revert it, it's more about openness then finality on the level of the policy." **(I2)**
Transaction Reversal	Decision on reversing unintended transactions.	"Once the currency is sent, its sent to that private key and there is no **way to retrieve** it back." **(I1)**
		"The user, the user is responsible for their own actions on the network, there is no corporation, there is no way for the development team or the miners to reverse the transaction or correct any error transaction. **You send the money and its gone**." **(I8)**

The former regards the content written to the ledger, either from single (e.g. land registries) or multiple parties (e.g. Bitcoin). The latter regards transaction validation and data preservation, steered through a blockchain's protocol and the use of consensus algorithms on a transactional level [12], [38], of which proof-of-work, and increasingly proof-of-stake, are used. Both factors together, define data quality on the ledger and have been found of paramount importance in the literature [21], [39].

System Architecture Development (SAD). The decision on the System Architecture Development describes who decides over requirements and functionalities of the initial as well as consequent blockchain system. E.g., which technology shall be used, or ensuring the system's interoperability when concatenated with other systems. This task is delegated in some application domains to open source developers, others are dependent on a professional software development team.

System developers will tailor an IT solution always to their interpretation, which causes a natural dependency [40]. The same holds true for blockchain systems, on which developers have major influence. As suggested by Glaser [41], Walport [3], and Hsieh et al. [42] the actors who develop and maintain a blockchain's system are key stakeholders and hold major influence. Echoing the work of Weill and Ross [19], this decision refers to "IT Architecture" and "IT Infrastructure Strategies".

Membership (M). Membership refers to granting or denying requests to partake in the network [35]. This decision is non-existent for public and permissionless blockchains, as there is no actor to control permissions to participate in the system, whereas in private and permissioned blockchains, read and write permissions are monitored by a central locus of decision making. For those systems, Okada et al. [35] stresses the importance of a trusted authority who has the power over the system and can grant or deny permission to participate in the system.

Ownership Disputes (OD). This decision is applicable only to applications where a wallet or token represent a belonging to a user, such as in cases regarding land registry or intellectual property rights. As found in our cases, there may be disputes over the ownership of assets, such as land property documents or intellectual work among the users. Ownership could thereby be falsely assigned to more than one party or revoked too soon. In traditional systems, courts are involved in resolving such conflicts [43], [44]; on blockchains, however, there is a need to identify actors who resolve conflicts when multiple users claim for the same property.

Transaction Reversal (TR). This decision refers to the case when the actor, intentionally or unintentionally (e.g. hacks), performs an unintended transaction, e.g. the transfer of assets to a wrong account, and wishes its reversal. The corresponding decision would reverse or correct the erroneous transaction. In all the researched application domains, there is no actor in charge of this decision, even though evidence of erroneous transactions has been found. This decision challenges the blockchain's dogma of immutability but has been deemed necessary in case of major damages. The process of reversing transactions is fierce, but possible, when a consensus among major stakeholders within and around a blockchain system is reached [21].

4.2 The Prospect of Blockchains for Changes of Governance

Deriving core decisions for blockchain systems (RQ1) served as a lens to analyze how those decisions translate into practice (RQ2). In the following, we illustrate their enactment on studied cases divided by domains.

Supply Chains (SCs). Calls regarding supply chain inefficiencies and the need for informational and processual integration and transparency are echoed for decades [45], [46], but often went unheard [1], [2]. Our sample inheres four cases from the supply chain domain, partly varying in motivation to apply blockchain technology. C3 (platform developer, hence not mentioned in the table) and C9, e.g., target the product flow (Know-Your-Object) for not only cost efficiencies but transparency along the supply chain. C7, on the other hand, utilizes IoT-sensors for good distribution practice, measuring and guaranteeing the temperature of medical goods to other supply chain participants.

Table 4. Decisions mapped to Supply Chain Cases

	Case 7	Case 9	Case 11
DM	External Consortium	External Consortium. State sets standards.	External Consortium. State sets standards.
SAD	Developers propose, consortium decides	Focal company in collaboration with state agency	Company decides, Consortium prioritizes
TR	Individual user's responsibility	Individual user's responsibility	Individual user's responsibility
OD	Appeal to courts	Appeal to courts	Appeal to courts
M	Not applicable	Not applicable	Port authority with companies
DA	Sensor-based, Cons.-Algorithm	Consensus Algorithm (PoS)	Contractual (Smart Contracts)

C11, a port administration in Belgium, aims to automatize the check-in and check-out of its hundreds of daily customers and their containers, storing a unique identifier for each of them in their blockchain system.

As it can be seen from table 4, the decision rights for Demand Management are centralized in consortia's, where formal consensus among stakeholders has to be found. This is also due the permissioned nature of all blockchain systems. As case 11 regards a public function, the state imposes standards. Consortia and their (business) users exhibit consequently power over the system's architecture and its further development. As for the Transaction Reversals, all three use cases do not foresee measures to reverse those; this may be due to the fact that none of those cases is operational, yet. In case of ownership disputes, all cases refer to courts. As for the Membership, the systems of C7 and C9 plan to become permissioned and public: users may hence read entries, but validation is permissioned. Data Authenticity is assured through mining on C7 and C9, while C11 utilizes permissioned solution.

Land Registry (LR). The prospect of registering land on a blockchain gained increasing attention in the last years, predominantly in developing countries, where trust in authorities tends to be weaker. Not only third parties are tried to be replaced by blockchains, but also the digitization of paper-based and lengthy processes, and cost reductions are sought for. Our sample considers four systems (C1, C2, C5, C14), whose goals overlap but slightly differ.

Table 5. Decisions mapped to Land Registry Cases

	Case 1 / 2 / 14	Case 5
DM	Dictated by state agency	Dictated by state agency
SAD	State agency and associated actors	State agency
TR	Appeal to courts	Appeal to courts
OD	Appeal to courts	Appeal to courts
M	State Agency and affiliates	State Agency and affiliates
DA	State Agency, Auditors	State Agency, Auditors

As a state function is performed, the state maintains the control over the System Architecture and Development as well as standards or enhancements. Further, the state assures Data Authenticity through the ledger, through concatenation of different blockchains, as well as through closer collaboration with affiliates (notaries, banks), using auditory nodes. In case of Transaction Reversals or conflict resolution, a user must appeal to court. While the partaking actors in the ecosystem do not change, users still benefit from transparency and reliability of records.

Cryptocurrencies (C). The case of blockchain-based cryptocurrencies concerns the first application area of blockchains overall. Cases 4, 6, as well as 8 illustrate our cases' decision placement below (case 14 refers to a consortium and is hence not listed).

In contrast to the previous cases, the blockchain-based cryptocurrencies are mostly built on public and permissionless ledgers, thus allowing members to partake in System Architecture and Development (via community discussions and votes and all the typical processes of FOSS) as well as Data Authenticity through mining (validating).

Table 6. Decisions mapped to Cryptocurrency Cases

	Case 4 / 15	Case 6	Case 8
DM	Users propose enhancements, developers decide	Team lead and two software developers	User propose enhancements, auditors decide
SAD	Group of core developers	Anonymous developers	Company's core team members
TR	Individual user's responsibility	Individual user's responsibility	Individual user's responsibility
OD	Not applicable	Not applicable	Not applicable
M	Not applicable (Permissionless)	Not applicable (Permissionless)	Not applicable (Permissionless)
DA	Consensus Algorithm	Consensus Algorithm	Consensus Algorithm

In all systems, there is a group of core developers implementing the majority's will – to their interpretation. There are limited measures (forks), however, if users conduct unintended transactions or seek for support in disputes of asset ownership, which points at blockchain's irreversible characteristic. The initial design of the platforms, however, lays in the hands of its founders.

Intellectual Property Rights (IPR) Management. As for intellectual property rights management, we interviewed three experts from two companies (C10, C13). Those projects aim to ease the management of intellectual property rights through unique identifiers and instant charge for usage of copyrights. Traditionally, those processes can be considered non-transparent and bureaucratic. The cases below illustrate the aspired blockchain system and their decision placements.

Table 7. Decisions mapped to IPR Cases

	Case 10	Case 13
DM	Company decides based on community vote	PoC: Consensus among stakeholders
SAD	Foundation, software provider	Company's core team members
TR	Individual user's responsibility	Individual user's responsibility
OD	Appeal to courts	Appeal to courts
M	Not applicable (Permissionless)	Not applicable
DA	Community-based	Consensus Algorithm

As for the Demand Management, both systems vary in terms of decision-making power: While case 10 emphasizes the rather open, community-based vote, case 13 utilizes a permissioned system. Being backed by a foundation, case 10 derived its initial system architecture in collaboration with its users;

case 13's design is based on developer's choices. As for ownership disputes, both systems refer to actual courts. Data Authenticity is assured through consensus algorithms and the access to all transactions is public.

5. Discussion

In the results section, we have distilled the major decisions that blockchain systems have to conduct. This answered RQ1. To answer RQ2, we have shown how those decision rights are mapped in a variety of cases. To complement RQ2, the fashion of their enactment, a wider discussion follows. Considering the matrices produced by matching the main aspects of decision-making and the empirical domains of application, we distilled the main points that characterize blockchain governance and thus influence the types of decisions to be made (RQ1) as well as their enactment (RQ2): a) External legitimation, b) reduction of discretionality, c) patrolling borders, and d) temporal management.

External Legitimation. Blockchain technology finds its origins in the rejection of external authorities but, interestingly enough, states and other authorities are now deploying blockchains. Even if in most cases their control and power over these multi-party systems is relatively limited, when they are present their role is not marginal as it can be seen in the rather centralized decision-making placement in cases 1, 2, 14, and 5. Indeed, especially when the state weights in, legitimacy is outside of the consensus mechanisms inscribed and deployed by blockchains. The most evident outcome of state presence is the possibility of some sort of appeal that, contrary to the dogma of immutability [11], allows to revert undesirable entries on the ledger, or exercise further control, like excluding undesired actors. This centralization of major decision rights, which may hence correspond to the hierarchical idealtype [16], raises the question if those prospected solutions indeed overcome core problems found nowadays in and around land registries [47], [48]; e.g., decisions on Data Authenticity as well as on reversing transactions would remain in the hands of the state or state-dependent actors (notaries). The prospected efficiency gains, however, seem highly desirable.

Reduction of discretionality. Since blockchains are basically consensus mechanisms, ad-hoc decisions (i.e. discretionality) are intended to be minimized to the early stages of rules settings. Once they are built in algorithms, human intervention ends up being reduced, to the ideal extreme of people remaining 'out of the loop'. Despite this, enhancement, membership and off-the-chain conflict resolutions leave the door open for ad-hoc decision-making as it can be seen in our case sample: Conflict resolution remains not in place or through real-life courts, membership is either regulated through gatekeepers or entirely open, and discussions on Demand Management is either enacted hierarchically (land registries), in consensus among few (supply chains), or in consensus among many (cryptocurrencies). This informality stands in contrast to the deterministic fashion in which smart contracts function [28], which questions smart contract adoption maturity [29]. Thus, automatic and human decision making appears to take place side-by-side, sometimes in competition, but algorithmic governance is merging with, rather than substituting, other modes of governance.

Table 8. Overview on Cases and Decision Placement

Case	Domain	DM	SAD	TR	OD	M	DA
7	SC	External Consortium	Developers propose, consortium decides	Individual user's responsibility	Appeal to courts	Not applicable	Sensor-based, Cons.-Algorithm
9	SC	External Consortium	Collaboration with state agency	Individual user's responsibility	Appeal to courts	Not applicable	Consensus Algorithm (PoS)
11	SC	External Consortium.	Company decides, Consortium prioritizes	Individual user's responsibility	Appeal to courts	Port authority, priv. companies	Contractual (Smart Contracts)
1/2/14	LR	Dictated by state agency	State agency and associated actors	Appeal to courts	Appeal to courts	State Agency and affiliates	State Agency, Auditors
5	LR	Dictated by state agency	State agency	Appeal to courts	Appeal to courts	State Agency and affiliates	State Agency, Auditors
4/15	C	Users propose, dev. decide	Group of core developers	Individual user's responsibility	Not applicable	Not applicable (Permissionless)	Consensus Algorithm
6	C	Team lead and engineers	Anonymous developers	Individual user's responsibility	Not applicable	Not applicable (Permissionless)	Consensus Algorithm
8	C	User propose, auditors decide	Company's core team members	Individual user's responsibility	Not applicable	Not applicable (Permissionless)	Consensus Algorithm
10	IPR	Community votes, company decides	Foundation, software provider	Individual user's responsibility	Appeal to courts	Not applicable	Community-based
13	IPR	PoC: Consensus among stakeholders	Company's core team members	Individual user's responsibility	Appeal to courts	Not applicable	Consensus Algorithm

Patrolling borders. Related to the previous, it is remarkable how in permissioned blockchains, patrolling the borders is an effective control mechanism. In fact, once one is in, preset rules apply, keeping actors out is a way to avoid undesired behaviors. Governance issues from other cases such as centralization of mining power, coordinated takeovers [9], or even take-downs [20] are hereby counterbalanced through a steering body and a walled-up system. Unless another actors' identity is stolen, the blockchain avoids unwanted access [11]. Even then, the clear audit trail of a blockchain [27] would allow to retrace misbehavior and reverse transactions (in permissioned systems).

Using unique and verified identifiers is well exemplified by the case of a Belgian's port authority (C11), where the monitoring of in- and out-flow is automatized, reducing governance costs of oversight. In more general terms, controlling the inflow and outflow of any resource can be an effective management tool.

Temporal Management. Last but not least, most cases show some sort of temporal dimension in the form of enhancements, access control of new members, and reversion of transactions, which is in line with other operational blockchains [9], [20]. As for all information systems, the analyzed blockchain cases were initially designed to a core group's interpretation [40], which might have been misled, still placing those as key stakeholders exercising major influence over those systems [41], [42]. All these add human dimensions to decision making and spread human influence over long periods of time. This rather long-time frame could be problematic for management because this new type of systems may not live, at least in its current forms, as long as the functions that it is intended to perform. This opens the problem of future transitions to new technologies [30], [49] and for one, it points to the formerly introduced notion of tribal behavior [8] of users.

6. Conclusion

This research studied the governance on and around blockchain systems through the lens of six core decisions on blockchain systems: Decisions on Demand Management, Data Authenticity, System Architecture Development, Membership, Ownership Disputes, and Transaction Reversals. Illustrating their enactment on empirical cases guided our understanding how power in those cases is distributed and in which fashion (algorithmic, ad-hoc, formal). Our results show various forms of enactment and a new division of labor between human and algorithmic decision-making.

Of course, this research is not free from limitations. First and foremost, governance, implicit or explicit, emerges in practice and over time. The field, however, especially for permissioned blockchain systems, can be considered in its infancy. So, the amount of solid cases remains limited. Our research, therefore, rather than making conclusive statements, strives to highlight emerging problems in an exploratory manner.

Our research not only answers the call for further research on governance in and around blockchain systems, but also anticipates the consequences of those decision in practice, which may also afftect practitioners.

In conclusion, it is worth to consider, for further empirical research, if those systems of blockchain end up in letting users to have more influence on decisions, or if they are ultimately deprived of what is automatized by consensus algorithms. One way or the other, following what and when people put their trust in, is a promising way to understand blockchains in practice.

7. References

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