Limitations of Trust and Legitimacy in Blockchain: Exploring the Effectiveness of Decentralisation, Immutability and Consensus Mechanisms in Blockchain Governance

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Abstract:

Purpose

This paper examines to what extent blockchain creates legitimacy and trust in different modes of public governance. It posits that while blockchain aims for political legitimacy through decentralising, immutable and consensus-based mechanisms, the execution of these mechanisms is limited in legitimating governance, which has knock-on effects on trust. It provides an original contribution by recontextualising and reframing blockchain as a governance mechanism that should, and must, perform a legitimating function in order to engender trust.

Design and Methodology

The research adopts a comprehensive framework for understanding the legitimacy of blockchain governance, positioning it in terms of co-governance, self-governance and hierarchical governance modes. It systematically analyses blockchain whitepapers, legislation, government documents and other sources in three paradigmatic case studies where blockchain governance failed. These cases are then used to assess blockchain according to three key characteristics of decentralisation, immutability and consensus.

Findings

The research finds that blockchain's use in governance settings still relies on legitimacy conferred from other sources – namely state – in order to generate trust. Significant limitations in its de facto political decentralisation, immutability and consensus protocols can create failures in co-governance, self-governance and hierarchical-governance applications, thus limiting the legitimation function of blockchain in facilitating political trust.

Originality and Implications

These findings are significant in highlighting blockchain's limitations as a decentralised, immutable and consensus-driven legitimating tool, which has knock-on effects on trust in technology and governance more broadly. It also has broader implications in more clearly highlighting the interconnectedness of political trust and legitimacy in governance processes.

Introduction

There is something quaint about the current hysteria around blockchains, in that they embody a touching belief that software will somehow provide a remedy for the untrustworthiness of people, institutions and government in our modern world. John Naughton, The Guardian, 12 March 2022

Significant debate about blockchain revolves around the nature of trust – arguing whether it is 'trustless' (Nakamoto, 2008), a shift from trust in individuals to systems (Werbach, 2020) or whether it is a 'confidence machine' (de Filippi et al., 2020). At the same time, it is argued that blockchain that can create fairer and more legitimate governance mechanisms such as voting systems, social income redistribution and public works projects (Chow, 2022a; Buterin, 2023). However, blockchain's role in engendering trust by creating legitimacy through its governance structure is not explored in great detail. This paper argues that in order to create trust, blockchain must be seen as legitimate, and perform a legitimating role in governance. It intends to fill a gap by examining not *whether* blockchain creates trust or confidence, but how this trust is created (or not) by perceived legitimacy in blockchain governance. In other words, it reframes the debate on blockchain around whether, and how, it is legitimated, and legitimates, governance functions. The key research question the paper addresses is:

To what extent does blockchain create legitimacy and trust in different modes of governance?

This paper contends that it is not trust that is important in blockchain, but rather the legitimacy that potentially creates the trust in the system. Blockchain aims to address the 'supply' side of trust by creating a new legitimating mechanism by which trust can be conferred, but its approach to trust needs to match up to the 'demand' side trust based on legitimate authority. By examining paradigmatic case-studies of blockchain governance in different governance modes - the Ethereum hard fork (self-governance), DAOs (co-governance) and China's Blockchain-based Service Network (hierarchical governance), the paper argues that blockchain's use in governance settings still relies on legitimacy conferred from other sources in order to be trusted by the public.

This research addresses key practical and academic considerations in our understanding of blockchain. The paper's main contribution is conceptual and theoretical, examining blockchain through the lens of governance modes to identify how it shapes or affects traditional conceptions of legitimacy in governance. It examines the relationship between blockchain, trust and legitimacy, and further develops this connection by extending the focus beyond governance *of* blockchain to examine blockchain's effects on legitimating governance itself. It provides an understanding of blockchain's effectiveness as a governance mechanism, including the actors, responsibility and accountability necessary in these systems, a gap identified in previous literature (Lapointe and Fishbane, 2018; Nascimento et al., 2019, p. 106; Lustig and Nardi, 2015). Practically, blockchain is touted as a unique political solution that 'promotes the empowerment of citizens…can improve transaction cost efficiency…[and] can democratise data and improve trust and transparency' (European Parliament, 2018). This paper makes a contribution by looking at whether these assertions play out in practice.

The paper first explores conceptions of trust, legitimacy and governance as they relate to blockchain. Through the lens of governance modes, the paper then explores three paradigmatic cases of blockchain governance in practice as examples of co-governance, self-governance and hierarchical governance: Decentralised Autonomous Organisations (DAOs), the Ethereum hard fork and China's Blockchain-based Service Network (BSN), respectively. The paper concludes by assessing the

legitimising functions performed by blockchain as a decentralising, immutable and consensus-driven technology and the implications this has for blockchain use in the public sector moving forward.

Theoretical Background and Literature Review

Blockchain as a technology is essentially a distributed ledger, where information is recorded on a series (or chain) of data blocks, where each block is connected to each other in a chain of information (for a summary of the technology, see, for instance Kassen, 2024). Blockchain, as a distributed ledger technology, has several key characteristics. First, it is *decentralised and distributed*, with the former meaning power and decision-making is disbursed, and the latter meaning that the technology is also dispersed across nodes. Blockchain is *immutable*, in that any changes, once made, cannot be reversed. Finally, blockchain is *consensus-based*, in that changes to the blockchain need to be agreed by some mechanism to take effect (Zachariadis et al., 2019, p. 109). Given these characteristics, its use in public administration and governance has expanded where it can theoretically fulfil many government and governance functions, from identification, personal records, land title registries and contract management to financial services, voting, providing benefits and streamlining bureaucratic processes across agencies and sectors (Berryhill, Bourgery and Hanson, 2018, p. 25-28). However, its use in these settings can affect how decision-making, consensus, accountability, control and organisation of governance operate (Tan, Mahula and Crompvoets, 2022), which has knock-on effects on how people trust governance and whether they see it as legitimate.

Trust

Trust in blockchain has its roots in broader debates about online trust. In the online sphere, uncertainties about actors, technologies and processes create risk and exposure to vulnerability. In addition, while offline trust often has a person or institution as its object, online this trust is usually transferred to the technology itself (Beldad, de Jong & Steehouder, 2010, p. 860). While debates about blockchain have mostly moved on from seeing it as an idealistic 'trustless' system (Benbunan-Fich and Castellanos, 2018, p. 2; Glaser, 2017; de Filippi et al., 2020), blockchain does remove the need for a trusted third party in many applications by relying on blockchain to execute these contracts. However, trust is not completely removed. A recent study found that 'when it comes to more complex social relationships, involving sharing of resources and assets, blockchain technology alone does not suffice for people to develop trusted interactions' (Pazaitis et al., 2017, p. 6) in (Hawlitschek et al., 2018, pp. 59–60). Furthermore, while blockchain can create situations that may facilitate trust, 'a condition is having the necessary institutional arrangements in place that can be trusted' (Ølnes et al., 2017, p. 360).

This makes trust an uneasy fit for blockchain and a contested one in the academic literature, where there is little agreement on whether the technology requires significant trust or none, and whether it builds trust or erodes it. The benefits of blockchain – consensus, immutability and decentralisation – do not lend themselves to the leap of faith and sense of risk associated with trust. Instead, as Filippi et al. argue, blockchain shifts the debate and motivations away from trust and towards confidence. This confidence is built on ideas of predictability, assurance and reliability and moves the focus to assurance in outcomes. However, those outcomes are still reliant on more than technology, and incorporate the actors, institutions and processes behind it (Filippi et al., 2020). As trust is reliant on these outcomes and perceptions of *performance*, it must conform to a set of *expectations* of institutions, which is provided by political legitimacy (Kaina, 2008, p. 514-15).

Legitimacy

Legitimacy in a political sense refers to the actor who is seen by citizens as 'rightfully holding and exercising political power' (Gilley, 2006, p. 500-501), which is based on expectations and acceptance of decision-making power, thus framing legitimacy as a precondition of trust (Kaina, 2008, p. 514-15). This flips existing research on the relationship between legitimacy and trust in blockchain on its head, where trust is most often viewed as existing apart from discussions of legitimacy (de Filippi et al., 2022, p. 31-32). Indeed, the two concepts may be co-dependent, and this paper fills the gap by looking at how legitimacy acts as a condition for developing trust.

However, *how* blockchain legitimates governance is complex (de Filippi et al., 2022). Connecting to Kaina's idea that trust is reliant on positive perceptions of (potential) outcomes, which presupposes that actors holding authority are legitimate, legitimacy can be understood as an interplay of inputs, outputs and throughputs, which refer broadly to participation, performance and process, respectively (Scharpf, 2009; Schmidt, 2013). Input legitimacy refers to opening the process up to more actors for political decision-making, with blockchain potentially allowing significant expansion of who can feed into these decisions. Output legitimacy refers to whether the interests of more stakeholders are met by certain outcomes. Finally, throughput legitimacy looks at the actual process of decision-making and efficacy, accountability and transparency, all issues that blockchain professes to tackle. In many ways, blockchain can be seen as a throughput mechanism, as it addresses process rather than actors involved, but at the same time, it influences the outputs created by these throughput mechanisms.

Governance

Blockchain's relation to public government and governance has been explored in terms of whether it recreates existing governance using new technology or represents a break in how we govern. In its nascent stages blockchain can reproduce existing issues with governance, like centralised rule-making and neo-colonial attitudes, or create a new, decentralised utopian view where technological innovations in decentralisation, immutability and transparency carry over to broader governance concerns (Cengiz, 2023, p. 455-457). Understanding this requires both 'on-chain' (i.e. how the technology itself is governed) and 'off-chain' (i.e. how that is translated into governance structures off blockchain) considerations, and as such research on blockchain governance needs to focus on it as an element of policy design with theoretical, technological, resource and managerial challenges to implementation (Tan, 2023).

How governance is designed may then take several shapes or modes. Kooiman (2003) identifies three modes of governance: self-governance, hierarchical governance and co-governance. This approach has also been updated as an organising framework in areas relevant to this work, such as algorithmic governance (Gritsenko & Wood, 2022), which shares with blockchain its potentially disruptive nature to existing governance mechanisms. *Self-governance* refers to a high degree of self-identity and socio-political autonomy in governance arrangements (Kooiman, 2003, p. 79). *Co-governance* refers to collaborative and cooperative forms of governance between several actors, including, but not limited to, networks (Kooiman, 2003, p. 96). Hierarchical governance displays 'a 'top-down' character: those governing are, or see themselves, as in some way superimposed above those governed' (Kooiman, 2003, p. 115). As blockchain governance is concerned with the 'direction, control and coordination of stakeholders' (van Pelt et al. in Laatikainen, 2023, p. 3), this paper explores blockchain through these three modes and examines decision-making, coordination and control through the key blockchain characteristics of decentralisation, immutability and consensus.

Bringing together the literature on blockchain governance, legitimacy and trust, the main contribution this paper makes is providing a more thorough examination of the processes that occur

between the technology and trust, namely how the technology is legitimated in order to engender trust. As such, it aims to fill several gaps in academic understanding of blockchain. Most broadly, there is a simple lack of engagement with blockchain from a political or public administration perspective (Tan, 2023, p. 493). The main gap this work fills is attempting to answer the question of how legitimacy can be actively gained or lost through its governance framework (de Filippi, 2022, p. 34). Literature bringing together governance, legitimation and trust of blockchain is scant. There has been some focus on how businesses try to legitimate their use of blockchain in corporate governance (Rosati, Lynn & Fox, 2021), but its use in public governance is underexplored (de Filippi et al., 2022). Indeed, 'legitimacy is one of the most important scarce resources' in blockchain governance (Buterin, 2021, in de Filippi et al., 2022, p. 23). Work on blockchain still tends to see legitimacy as something that exists or not, whereas the focus on *how* blockchain can lead to legitimacy needs to be explored. Finally, it also addresses the intersection of blockchain as a service tool and as a political governance mechanism, an area that requires further study (Kassen, 2023, p. 5). This requires a deeper understanding of why blockchain may succeed or fail as well as a systematic review of outcomes (Laatikainen, 2023, p. 11), with this research positing that success is related to its ability to be seen as legitimate.

Methodology

The paper uses a qualitative approach to examine paradigmatic cases of blockchain governance in practice, which 'are selected intuitively with the aim to "develop a metaphor or establishing a school for the domain that the case concerns"'. These then act as theory-development examples (Yin, 2009) of blockchain governance in the three governance modes outlined above (Flyvbjerg 2006, p. 230 in Gritsenko and Wood, 2022, p. 51). This approach provides an opportunity to develop conceptual models (Solomon, 2022, p. 2) of blockchain governance and legitimation, selected along the following criteria:

1. Identifying a salient governance issue and the process by which it is addressed;
2. Clarifying sets of actors and institutions who are affected and respond to this problem;
3. Focussing on cases where blockchain has clearly affected governance.
   (Adapted from Gritsenko & Wood, 2022, p. 51)

Table 1: Blockchain Use Cases and Modes of Governance

Case	Mode of Governance	Governance Issue	Actors/Institutions	Governance Effect
Ethereum Fork	Self-Governance	Immutability	Ethereum management, Ethereum users	Reversal of immutability
Blockchain-based Service Network	Hierarchical	Decentralisation	China, blockchain builders	Decentralisation 'in name only'
DAOs	Co-Governance	Consensus	DAO developers, DAO investors	Hierarchical co-option

The chosen cases are bounded and externally comparable to other blockchain governance cases (Solomon, 2022, p. 2). This case selection and methodological approach is appropriate as it acts as a coherence check on paradigmatic concepts underpinning blockchain's use in governance (Solomon, 2022, p. 4), namely decentralisation, immutability and consensus, testing the validity of these concepts as key benefits of improving trust and legitimacy of blockchain governance (Kassen, 2024).

Analysis of the three cases draws on all primary sources related to governance of the three cases, including blockchain white papers, original legislation, government documents, evidence given to government and interview transcripts with developers, where available. It also draws on discussion and debates on message boards related to the cases, as well as blog posts and editorials by key blockchain architects such as Sergei Buterin to provide first-hand context of how blockchain governance operates in practice. These sources were collected from websites related to particular blockchains (e.g. Ethereum.org), as well as message boards and existing interviews with those involved in the cases examined. These documents were examined through the lens of Kooiman's governance modes and analysed inductively for references to governance or governance-adjacent terms related to the scope of this study (trust, transparency, accountability, legitimacy, decentralisation, consensus) to establish policy or governance intention and outcomes (Karppinen & Moe, 2011, p. 9-10). In order to deepen this analysis and fill in any gaps, secondary sources such as news articles and academic analyses were also used. As this paper is focussed on governance mechanisms, only documents related to this were analysed without a focus on broader discourse around these blockchain use cases, apart from direct discussion of governance structures. By drawing on all primary sources (i.e. founding documents and white papers) related to these cases, bolstered by secondary analysis when appropriate, they fulfil Scott's requirements of using authentic, credible, representative and meaningful sources (Scott, 1990, p. 1-2).

Results: Blockchain in Practice

Blockchain as Co-Governance: The Case of DAOs

Decentralised Autonomous Organisations (DAOs) are organisations built on blockchain-created smart contracts as an alternative to traditional hierarchical organisational corporate structures. They work as a means of co-governance, where the aim is to develop a collaborative and cooperative structure built on consensus mechanisms. In many ways, a DAO 'essentially replicates the legal trappings of a traditional company or nonprofit but using only cryptographic blockchain technology for enforcement' (Buterin, 2014, p. 23). Part of the appeal of DAOs is their decentralised nature, allowing and in fact requiring consensus or majority votes for changes to organisational activities and structures. Many different types of DAOs exist (Chamria, 2023), but all have organisational structures that are 'governance-like', such as voting and decision-making mechanisms, and DAOs have been mooted as a way of providing public services and governance in areas like healthcare (Neumann, Harding & Davies, 2023). The number of DAOs has increased exponentially in recent years, and in October 2024 is estimated to be over 50,000 aggregated worldwide, with a market value of $24.5 Billion USD and over 3 million active voters (DeepDAO, accessed 01 October 2024).

DAOs can be seen as embodying two central tenets of blockchain: decentralisation and consensus protocols. Decentralisation needs to be further disaggregated as decentralisation of network architecture, and decentralisation of power (Walch, 2019, p. 42 in Hofman et al., 2021, p. 24). While decentralisation of *power* intends to distribute trust among various actors, rather than concentrating it at the centre, in DAOs 'users put their trust in the community, technology and code, rather than a regulated financial intermediary.' (Naudts, 2023, p. 11). In other words, trust is simply transferred, rather than removed, with consensus being achieved in different ways.

DAOs have significant potential limitations in governance consensus, surrounding issues like voting, leadership and legality. In terms of voting, of the over 50,000 DAOs created, only 441 (0.87%) have more than 100 token holders (i.e. voters) (DeepDAO, accessed 01 October 2024). Given the low number of voters, DAO decision-making and governance may not drastically improve consensus, defined as giving many people a voice in decision-making. In a study of 10 popular DAOs in 2022,

Chainalysis found that in all cases, 90% of governance tokens (i.e. voting rights) were held by less than 1% of all actors in the DAO. Voter turnout for DAOs is also extremely low, with nearly 50% of DAOs having turnout of less than 2%, and as DAOs increase in size, turnout tends to fall further (Fracassi, 2022, p. 14-15), allowing for majority holders to dominate these votes. A study of Compound and Uniswap backed this up, showing that only 10 vote holders held 57.86% and 44.72% of the voting power in those two cases respectively (Messias, 2023). Further rules around curating proposals that go to vote, dispersion, pseudonymity of voters and incentive structures for yes and no votes can limit DAOs' consensus-making power (Minn, 2019, p. 154-155; Mark, Zamfir & Sirer, 2016). In many cases, DAOs are found to be 'decentralised in name only' (Wharton BDAP Project, 2023, p. 11), or decentralised technically but not organisationally (Heo & Yi, 2023).

In addition, input mechanisms – represented in DAOs by voting – are subject to complications that do not affect traditional governance mechanisms in the same way. Firstly, if voting is based on tokenisation (as is most common), then voting can be co-opted by those with more tokens. This is a problem in most DAOS, given their high Gini Co-efficient, which indicates significant disparity in voting power between token holders, even in cases where alternative voting mechanisms may be used (Roubini, 2018; Rosenthal, 2018; Ferreira, 2023). This calls into question the entire *de facto* decentralisation of blockchain because of its concentration with a small number of users (Gencer et al., 2018; Gupta & Gupta, 2018). In addition, coin exchanges (which are often used to ease buying and selling of bitcoin through a centralised exchange) can undermine decentralisation of voting power and concentrate it in the hands of these exchanges (Rosenthal, 2023; Cheng, 2020). Finally, even if governance is technically open to all, consensus mechanisms such as discussion and feedback on changes are often confined to a small group of token holders (Jirásek, 2023) and vote buying can be a problem (Tan et al., 2023, p. 12). Unlike traditional elections, voters may not always be clear on what they are voting for, as votes are, essentially, for changes to code, which are easy to manipulate or misrepresent (Reynolds, 2023). It also leaves room for unintended consequences, for example in the case of decentralised finance firm Compound, where a routine upgrade to code created vulnerabilities allowing for the siphoning off of up to $162 million. Although the mistake was caught early, the blockchain's governance rules required a multi-day voting window to implement change, meaning the vulnerability was known and exploited for far longer than under traditional models of governance (Sigalos, 2021).

In terms of leadership, DAOs are also often not decentralised. The Blockchain Association recognises that 'Open-source and cryptocurrency projects often need or choose to have *some* centralized leadership, and at times considerable centralized leadership on their path to decentralization' (Blockchain Association, 2019). Some DAO users do not even see true decentralisation as an optimal outcome. 'If your token governance design, or your DAO, does not have executives, i.e. people who can take binding actions first, and only be punished after the fact, then you've designed a dysfunctional governance system' (Interviewee quoted in Augustin, Eckhardt and de Jong, 2023, p. 7). About the Swarm City DAO, one user noted '"The first governance structure you might say is something like a dictatorship…What we are trying to build is of course a totally decentralized open platform…But in order to make the tools, we need to do the governance in a really hierarchical way." (Interviewee quoted in Beck and Mueller-Bloch, 2018). The OECD has also noted potential centralisation problems that DAOs do not solve, saying that 'despite the so-called "decentralised trust", current practices of DAOs and DeFi markets have not solved some of the basic issues which corporate governance is intended to address, such as conflicts of interest and information asymmetries' (OECD, 2022, p. 23).

As a tool of co-governance, DAOs fail in ensuring key tenets of this mode, namely creating horizontal, decentralised governance. In blockchain terms, decentralisation is often *in name only*, with highly centralised leadership and voting mechanisms. In essence, blockchain offers a 'veil of decentralisation' that covers the actions of highly centralised key actors (Walch, 2019). Legally, DAOs are often unable to ensure effective consensus mechanisms and thus must fall back on traditional governance mechanisms to work (Minn, 2019, p. 142). This echoes the need for developing top-down, rule-based mechanisms to ensure effective algorithmic governance in other technological applications like sharing-economy platforms (Gristenko & Wood, 2022, p. 54-56). Thus, as a tool of decentralisation and consensus, DAOs illustrate the limitations of blockchain technology.

However, recent research does show that DAOs are more likely to be long-lasting if they incorporate good governance mechanisms within their infrastructure, especially in ways that improve accountability, decision-making and incentives, such as fair voting mechanisms (Rikken et al. 2023), although this must be established from the beginning. In addition, scholars still see potential value in blockchain for improving self-governance and decentralisation through e-participation, e-petition and e-voting applications, for instance removing the need for national election bodies to oversee fair elections (Kassen, 2023, 2024, p. 46; Olaniyi, 2024). In addition, DAOs for non-profit enterprises potentially offer improvements in legitimation through reputation-based voting, transparency, participation, equity and inclusiveness (Saito and Rose, 2023; Rikken et al. 2023, p. 473). Initiatives like Democracy Earth show the potential of blockchain in enabling youth participation (Kassen, 2023, p. 10).

Blockchain as Self-Governance: The Case of the Ethereum Fork

Ethereum is one of the most popular blockchain infrastructures and its role as a governance tool was recognised from its inception (Buterin, 2014). While it can be seen as a mode of self-governance, in that it has a strong internal organisation with an embedded governance framework, this self-governance also created a situation that violated two of the main governance principles of blockchain – its decentralisation and immutability. First, Ethereum also faces the centralising tendencies outlined above about DAOs. A recent study found that 10 individuals were responsible for 68% of all implemented Ethereum Improvement Proposals (a governance change mechanism), although this centralisation is decreasing over time (Fracassi et al., 2024). Second, in an example of immutability being undermined, The DAO (not to be confused with the generic DAOs discussed in the previous section) was, at the time, the most successful crowdfunding example of a decentralised autonomous organisation and seen as a new way of funding start-ups (The DAO, 2016). In 2016, hackers exploited a vulnerability in the Smart Contract code and were able to steal 3.6 million Ether (then worth $50 million USD). However, a waiting period was built into the Smart Contract, and the Ethereum community voted to create a 'hard fork', essentially undoing the hack by restoring the previous version of the blockchain. This created two competing versions of the Ethereum blockchain – Ethereum Hard Fork (ETH) and Ethereum 'Classic' (ETC) (Kohn, 2016). The fork split the community between those who saw the fork as necessary and those who still felt the code was law. 'The DAO wasn't robbed, it was poorly coded and someone exploited that. If contract is law then the exploiter was in the right'. On the other hand, 'People who signed up for decentralization or immutable code at all costs are part of an ideological minority with a deeply flawed world view' (both quoted in Augustin, Eckhardt and de Jong, 2023, p. 8). Supporters of ETC argued that the 'code is law' and that because ETH became dominant, this undermines the idea of immutability, as the initial hack was essentially undone.

'The Attacker', who claimed to undertake the hack, referenced existing legal governance mechanisms as a way to legitimate their actions. 'I am making use of this explicitly coded feature as

per the smart contract terms and my law firm has advised me that my action is fully compliant with United States criminal and tort law' (The Attacker, 2016). The DAO's terms also highlight the code as the ultimate authority, stating that 'The DAO's code controls and sets forth all terms of The DAO Creation." (quoted in 'The Attacker', 2016). The Attacker furthermore argued that 'a soft or hard fork would amount to seizure of my legitimate and rightful ether, claimed legally through the terms of a smart contract. Such fork would permanently and irrevocably ruin all confidence in not only Ethereum but also in the field of smart contracts and blockchain technology' (The Attacker, 2016). Undermining Ethereum's legitimacy was also raised by Covertress, founder of Krypton (a decentralised cryptocurrency exchange), who stated that 'Unless it does nothing and allows the funds to remain diverted, Ethereum will suffer a loss of credibility by effectively bailing out DAO investors and reversing what was billed as unstoppable code. And that sounds too much like the bank bailouts that Blockchain technology was in part designed to guard against' (Covertress, quoted in Aru, 2016).

In some ways, the Ethereum hard fork can be seen as an example of self-governance working, as the community majority voted for the fork. However, it still undermines the immutability of blockchain, and without effective decentralising mechanisms (which are hard to establish, as seen in the DAO case above), the removal of immutability can be problematic (Musiani, Mallard and Médeal, 2019, p. 142; Cheng, 2020). This was shown in the case of a hard fork when Steemit (a decentralised blogging platform) partnered with Tron, another blockchain/cryptocurrency provider. The Steem community responded by removing (through a soft fork) the voting power of a large number of tokens held by Tron in an attempt to limit the power they had over the community. Steemit and Tron then responded with a hard fork undoing the community's soft fork to ensure their companies maintained control of the blockchain (Cheng, 2020). Steemit/Tron justified their decision based on traditional legitimating mechanisms, namely the law, arguing that the soft fork was focussed on 'taking away their [Steemit's] rights and possession to their owned asset, and may be deemed illegal and criminal' and that the move was necessary 'to resume the order of the community' and 'protect the Steem blockchain from bad actors' (Steemitblog, 2020). Subsequent analysis shows that passive resistance to takeovers like Steem is likely insufficient to stop centralisation of control and ensure immutability, and any resistance is conditional on the initial governance design (Li et al., 2023). This echoes other research that shows that centralisation of blockchain decision-making in a way that affects immutability often occurs when unforeseen problems occur (Heo & Yi, 2023, p.60). Although centralisation measures may be temporary, they illustrate the 'shadow of hierarchy' in a supposedly decentralised and immutable system (Heretier, 2008; DuPont, 2017, p. 170-171). The risk of forking is possible in all blockchains. This can be a positive, in allowing for changes where there is wide consensus (Kassen, 2024, p. 44), but can be potentially problematic in divisive governance decisions where you would never break the chain (Buckingham et al., 1977).

Both decentralisation and immutability, core tenets of blockchain, have been repeatedly shown to be ambitions rather than reality (Zachariadis et al., 2019, p. 113), illustrated in this case and the case of DAOs more widely. The ex-post rationalisation of governance decisions shown in hard forks is in contrast to the ex-ante, design-based approach seen in other technological use cases, such as algorithms designed to combat disinformation in online media (Gritsenko & Wood, 2022, p. 53-54). It illustrates the limitations of self-governance of blockchain, with immutable decisions being reversed and hierarchies potentially reestablishing themselves in periods of crisis. Still, the potential immutability of blockchain, when overseen by trusted arbiters, can provide confidence and legitimacy in record-keeping applications where timely contractual requirements are clear, such as public procurement and urban planning (Kassen, 2024, p. 47-48). A concrete example of this is seen in Estonia's deployment of the technology in keeping personal records to ensure integrity and trust

in data, as well as quickly identifying breaches or attempts to change records (PWC, 2019). It could also potentially facilitate open law-making where changes are recorded and immutable to ensure complete transparency in political decision-making (Kassen, 2023, p. 15).

Blockchain as Hierarchical Governance: The Case of the Blockchain-based Service Network (BSN)

The Chinese government, through the China Academy of Information and Communications Technology (CAICT) under the Ministry of Industry and Information Technology, first started exploring blockchain in earnest in 2016, publishing an initial *White Paper of Blockchain Technology and Application Development in China*, which has been followed up by subsequent white papers (CAICT, 2016; 2018). These white papers recognise both the trust aspect of blockchain, and the potential concerns around decentralisation (CAICT, 2018). The Chinese government, through their State Information Center, is also lead partner in creating the Blockchain-based Service Network (BSN), which aims to provide blockchain services for new applications of the technology internationally (Quinn, 2023). Furthermore, in February 2023, the Ministry of Science and Technology approved the establishment of the National Blockchain Technology Innovation Center, through which it aims to train up to 500,000 experts in blockchain and its applications (ICSTI, 2023).

Blockchain is central to the Chinese government's governance plans (CAICT, 2018, p. 26), with Xi Jinping noting 'the importance of stepping up research on the standardization of blockchain to increase China's influence and rule-making power in the global arena' (quoted in Ekman, 2021, p. 5). This has led to explicit mention of blockchain in the country's 14th five-year plan, recognising the country's leading role in the technology, as well as aiming to 'progressively explore the establishment of governance principles and standards for…blockchain…[and] support the building of a secure and controllable low-level technology platform and blockchain open-source community with sustainable development' (Central Commission for Cybersecurity and Informatization, 2021).

China's approach to blockchain is focussed on *technical* decentralisation, while maintaining centralised control over power and governance issues (Kaiser, Jurado & Ledger, 2018; Harsano, 2022; Ma, 2021). As Chinese official Xu Hao said, blockchain is about 'de-intermediarization. There is no way to get rid of the center' (Quoted in Knowledge at Wharton, 2019). Within China, public blockchains are not allowed, meaning all blockchains in the country are permissioned and its customers and users are not anonymous, their activities can be tracked and content can be censored (BSN Development Association, 2020, p. 12; Knowledge at Wharton, 2019). Both decentralisation and immutability can thus be compromised (Ekman, 2021, p. 2-3), which is also highlighted in government documents (Supreme People's Court, 2022; CAC, 2019).

These examples clearly show that while China may embrace *technological* decentralisation, this does not extend to decentralisation of governance or power structures, which can be true of blockchain more broadly as well (Jensen, Wachter and Ross, 2021, p. 6). Instead of a tool of decentralising power, 'Beijing is developing a specific type of blockchain that is not only adapted to the authoritarian political system, but also has the capacity to strengthen it in some areas, such as policing and clamping down on dissent' (Ekman, 2021, p. 3-6; Fanusie, 2021). This extends to the attribute of immutability and transparency of the blockchain, which may be used to ensure citizens' activities are transparent and permanent but states' activities remain opaque (Cengiz, 2023, p. 456). As Vitalik Buterin, founder of Ethereum, noted in an interview with Time: 'The way I would describe the dystopian potential of centralized crypto is it allows governments and corporations to be authoritarian and lazy…The potential for centralized digital technology to reduce the costs of shutting down groups of people you find annoying is definitely very real' (Buterin, 2022). This danger of technological capture by vested interests can also be found in research about control of artificial

intelligence technologies, where potential governance innovation brought about by technology can be undermined by traditional governance structures (Ulnicane et al., 2020). Still, decentralisation afforded by blockchain may aid in areas such as decentralised notarisation, land use and personal records (Kassen, 2024, p. 46-47).

Discussion: Blockchain as a Legitimating Force: Unpicking and Analysing Decentralisation, Immutability and Consensus

This paper examines whether blockchain creates legitimacy and trust in different modes of governance by looking at three paradigmatic cases studies and analysing the promises blockchain makes and its role in improving inputs and/or outputs in governance processes. The three cases outlined above show that while blockchain offers a new technological approach to dealing with public services, it does not significantly disrupt or upend co-governance, self-governance or hierarchical governance modes in ways it promises – through decentralisation, immutability or consensus processes. In the case of co-governance, shown through DAOs, output legitimacy still rests on traditional legal-institutional frames, and trust – reliant on blockchain's consensus protocols – can be impeded by a lack of *de facto* decentralisation of decision-making. In cases of self-governance, as illustrated by the Ethereum fork, input legitimacy and trust were undermined by the reversal of its (flawed) governance mechanisms. Finally, in the case of hierarchical governance, blockchain is used as a legitimating mechanism by the Chinese government, but trust is undermined by the lack of *de facto* decentralisation.

This work makes a key contribution in further unpicking the role of trust in blockchain governance, showing that trust is reliant on the perceived legitimacy of blockchain, which in turn can be undermined by limitations in the key tenets of blockchain architecture, namely decentralisation, immutability and consensus. The paper also provides nuance to the conception of blockchain as a form of 'decentralised network governance' (Zwitter & Hazenberg, 2020). These paradigmatic cases show that while blockchain attempts to address policy throughputs with decentralising, immutable and consensus-based mechanisms, the execution of these mechanisms can be limited in legitimating governance in terms of inputs and outputs. Instead, it can act as a governance tool that still requires existing institutional mechanisms 'off-chain' in order to work (Filippi et al., 2020, p. 11; Allessie, et al., 2019). In legitimacy terms, it has limitations in increasing inputs (through a lack of de facto decentralisation and issues with consensus) or outputs (in terms of immutability). This has key implications and significance for the study of blockchain as a governance phenomenon, locating it more clearly as a potentially flawed governance tool than a new mode of governance.

Blockchain as decentralising force

As both the case of the BSN and the Ethereum fork showed, there are significant limitations to blockchain's decentralising nature. 'Current experiments of blockchain in public sector have largely continued to follow a mostly centralised governance logic, where the government retains a vast amount of the decision-making power' (Allessie et al., 2019, in Ubaldi, et al., 2019, p. 40). While decentralisation of blockchain *architecture* is seen as a positive, decentralisation of decision-making and organisation is more contested. This largely supports previous research that has questioned the total decentralisation of blockchain governance, decoupling decentralisation of architecture and decentralisation of process (Hsieh, Vergne and Wong, 2019, p. 50; Buterin, 2017). Furthermore, it provides additional evidence that even decentralised blockchain requires centralisation in its setup, where governance rules are agreed (Lindman, 2020, p. 51; Zachariadis et al., 2019, p. 108; Ølnes, Ubacht & Janssen, 2017, p. 363; Lemieux and Feng, 2021, p. 145-46).

Blockchain as consensus building technology

As DAOs and the Ethereum fork shows, 'off-chain' consensus on blockchain's use is just as important as 'on-chain' blockchain consensus mechanisms. The idea that technology can be designed to be fully impartial, unbiased or apolitical to existing human-led institutions ignores the fact that all 'artifacts have politics' (Winner in Filippi et al., 2020, p. 7). In other words, the findings in this paper support the idea that someone 'off-chain' still needs to make the rules governing blockchain (Werbach, 2018, p. 134), and this creates a need to examine how consensus is built to make decisions on blockchain. As the UK government notes about permissioned blockchains, 'the ledger's integrity is checked by a limited consensus process. This is carried out by trusted actors' (UK Government Chief Scientific Advisor, p. 17).

Blockchain as immutable record

As the BSN and the Ethereum fork show, immutability is more of an ideal state for blockchain than a realistic one, with the possibility of decisions being rolled back in certain circumstances. These findings go somewhat further than other work. The OECD notes that 'data on the blockchain may be immutable and easily auditable, but confidence in that data is only as high as confidence in the processes that placed that data on the blockchain to begin with…In most situations the technology also benefits from (or requires) trusted parties existing somewhere in the ecosystem' (OECD, 2022, p. 38). This paper shows that trusted actors are in fact a necessity in underpinning blockchain's auditability when even the underlying technological architecture can be mutable in certain circumstances. Furthermore, immutability may not always be a positive in governance settings where immutability 'may mean that systems are resistant to legitimate political authority' (Werbach, 2018, p. 104).

Blockchain as a trust and legitimacy builder

A fundamental issue with blockchain is that trust typically relies on legitimate *processes* designed centrally, and decentralised *technology* like blockchain does not replace or disrupt the need for centralised processes governing technological usage (Lindman, 2020, p. 17). This research supports that point. Blockchain cannot replace traditional modes of trust and can only act to promote what is already underlying it institutionally (Ølnes, Ubacht & Janssen, 2017, p. 360). Therefore, its limitations in *technological* decentralisation, immutability and consensus also result in limited application in creating decentralisation, immutability and consensus in *governance*.

This paper also makes the contribution that Blockchain's use for legitimacy is largely tied to traditional legitimation mechanisms. As Justin Drake, a key developer of Ethereum states, 'Whenever you have a boundary between two systems, you have to play by the rules of both systems simultaneously' (quoted in Chow, 2022b). 'If cryptocurrencies are not decentralized and trustless, what is their point? Users have simply switched from trusting visible, regulated, accountable institutions backed by the legal system, to invisible, unregulated, unaccountable parties effectively at war with the legal system' (Rosenthal, 2023). This research shows that if blockchain cannot be seen as either a legitimate, or a legitimating, force in governance, it can have a negative impact on trust and confidence in the system as a whole (Filippi, p. 4-5). This is not to say *all* uses of blockchain are problematic or should be avoided. However, these paradigmatic cases illustrate the governance problems that *can* arise with blockchain given its current technological and implementation infrastructure.

Conclusions, Limitations and Lessons for Governance and the Public Sector

Drawing from the cases above, blockchain has some use in governance as a *tool* rather than a *disruptor.* However, lack of disruptiveness does not mean it cannot be valuable for the public sector, which by its nature should avoid disruptiveness and focus on granular and concrete functions (Lindman et al., 2020). Gains in blockchain can be incremental in areas such as information validation, supply-chain management, notarisation, small-scale participatory mechanisms, land use and other record-keeping (Kassen, 2024; Jimenez-Castillo et al., 2023). There are two key lessons for policy-makers in more effectively considering blockchain in governance. First, blockchain should only be used when it adds value to existing approaches and be needs-, rather than technology-driven (OECD, 2018; Lindman, 2020, Ølnes, Ubacht & Janssen, 2017, p. 362). In other words, blockchain should be treated as a means to an end, rather than the end itself, with clear *governance* goals identified before considering whether blockchain is an appropriate solution.

Second, blockchain's use must be acknowledged in policy design and not just implementation (Tan et al., 2022, p. 2; Gritsenko & Wood, 2022). Technically, proper validation of public information needs to be ensured through proof-of-authority mechanisms, and clear rules should govern either who can access permissioned blockchains or how permissionless blockchains ensure reliable information. Validity and thus legitimacy can be ensured through open-source coding (Kassen, 2024, p. 51) and crowd sourcing of data checking, such as that seen in the City of Vienna, which allows citizens to check municipal records through blockchain hashes to ensure validity (Kassen, 2023, p. 13). Consideration must be paid to balancing immutability of records and 'right to be forgotten' legislation (Kassen, 2024, p. 51-52). Ex ante consideration of what blockchain does better than existing governance mechanisms would ensure proper and efficient usage. Here, blockchain's consensus mechanisms can enhance co-created governance mechanisms and allow for transparency and accountability, as long as pre-existing rules are established to ensure alignment with existing regulatory, legal and policy frameworks and requirements (OECD Council, 2022; Cagigas et al., 2023). In all cases, governments must still act to coordinate, gatekeep and mediate technological usage through existing governance mechanisms to ensure that blockchain is used effectively (Zwitter & Hazenberg, 2020, p. 10). As a large portion of crypto users believe blockchain governance should mainly be done 'on chain' (45%) with no human element (30%), and nearly 40% believing that regulation will do more harm than good (Korpas, Frey and Tan, 2023, p. 4-6), people need to be made aware of the transparency, accountability and legitimacy limitations of relying completely on governance within the blockchain.

As regards trust, blockchain is likely more useful in traditionally low-trust governance environments (Ma and Huang, 2022; Ubaldi et al., 2019, p. 40) as a potential 'architecture of trust' (Bustamente, 2022, p. 12). This can enhance sometimes-flawed traditional governance approaches to activities such as voting and participatory decision-making. However, it does not act as a replacement for institutional trust and still relies on traditional governance mechanisms for legitimacy (Brookbanks and Parry, 2022; Cagigas et al., 2023, p. 405). In areas where public trust is high, benefits from blockchain likely lie more in the areas of efficiencies and security in delivery (Ubaldi et al., 2019, p. 41; Allessie et al., 2019), for example in record-keeping (e.g. personal records and property ownership), or in using smart contracts to improve supply chain management and business-to-government information sharing. Trust and legitimacy need to be built into the governance design underpinning blockchain applications (Tan, Mahula and Crompvoets, 2022, p. 2), as the above cases show it is difficult to implement at a later point. This also points to the fact that there needs to be proactive and deliberate *political* integration of decentralisation, consensus and immutability, as blockchain only facilitates these features technologically and not as governance design features (Zwitter & Hazenberg, 2020, p. 3). However, blockchain's governance consensus mechanisms can

also act to undermine the extent to which governance can be designed ex ante, unlike with algorithmic governance (Gritsenko & Wood, 2022), which may limit its effective use.

The paper develops a theoretical and conceptual framework based on governance modes to test blockchain use cases and their viability as mechanisms of different governance modes, and as such is somewhat limited in generalisability. The framework established here illustrates blockchain's limitations in governance but also opens the door to future qualitative and quantitative research applying this framework to emerging uses of blockchain in public governance. This paper has filled gaps in exploring the role of blockchain in legitimating outcomes in order to improve trust, but more attention also needs to be paid to examining blockchain governance design and how it can best leverage the technology's advantages in consensus, immutability and decentralisation. The political nature of these features, rather than just the technological advantages, also warrants further study. Finally, if blockchain lays claim to building trust and legitimacy in governance, the effects of the technology on people's attitudes needs to be explored in more depth. These avenues of research can connect the dots between blockchain design and usage in a way that ensures that the technology is deployed in a way that considers its functions as a trust and legitimation mechanism.

There are some limitations to this study. It acts mainly to show potential and actual limitations in the application of blockchain technology, but it spends less time examining best-use cases or ways in which these limitations can be overcome. Second, there is room to develop this research further by employing different methodological tools to explore blockchain governance at the macro level rather than focussing on single-use cases. Finally, the focus of this paper is on blockchain architecture as laid out in governance frames like blockchain whitepapers, but there is additional room to explore the outcomes, perceptions and impact of these governance structures in practice.

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