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Exploring Decentralized Autonomous Organization (DAO) Governance: An integrative literature review

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Abstract

Decentralized Autonomous Organizations (DAOs) have emerged as blockchain-based organizations enabling novel forms of self-governance and tech-enabled organizing. In this paper, we focus on the governance of DAOs. DAO governance is a dynamic human-machine governance system transforming how online communities work, organize, own and co-govern their projects in the digital realm. In this article, we review one decade of multidisciplinary research of organization, management, and information studies to understand the implications of DAO governance. Our review reveals the main concepts that explain DAO governance mechanisms, processes, actors, and typologies. Our review also highlights the main challenges DAO governance faces. We propose using Polycentric governance theory to face these challenges and open new streams for future research on DAO governance.

Keywords: Blockchain; DAO; DAO governance; smart contracts; tokens

1. INTRODUCTION

Decentralized Autonomous Organizations (DAOs) have emerged from the development of blockchain smart contract systems like Ethereum (Buterin, 2014). The First DAO appeared in 2017, "The DAO", as a venture capitalist organization for funding projects in the Ethereum ecosystem (Jentzsch, 2016). Since then, many DAOs, such as MolochDAO, Aragon, Bisq, MakerDAO, DAO stack, Colony, Arbitrium, Optimism, etc., have emerged. These DAOs have various purposes, from funding public goods, blockchain infrastructure or Defi (Decentralized finance) to venture capitalists (Wang, Q. et al., 2023). However, they share a common trait in experimenting with novel forms of self- governance and tech-enabled organizing (Ziegler & DuPont, 2023).

DAOs are blockchain-based organizations surrounded by a network of contributors that pursue common purposes and share goals without any managerial hierarchy (DuPont, 2018). DAOs work under four main principles: Decentralized, Autonomous, Organization, and Open network. Decentralized refers to a process in which humans and machines adopt and perform different roles and tasks without any managerial hierarchy (Qin et al., 2022). Autonomous because its governance and management rules are automated or partially automated using smart contracts (Wang, S. et al., 2019). Organization because grants to its contributor's ownership and management rights (Qin et al., 2022). Finally, it is a permissionless network where anyone can join and leave whenever they want (Wang, Q. et al., 2023).

We define DAO governance as dynamic human-machine governance system that comprise design principles, mechanisms, processes, actors, and market dynamics. DAO governance systems enable online communities to self-govern, organize and develop blockchain-based applications. The key distinction between DAOs and

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open-source communities is the use of smart contracts and governance tokens to automatize, own and govern the blockchain protocols they developed without the backing of any company or institution (Ellinger, Gregory, Mini, Widjaja, & Henfridsson, 2023).

Academic research on DAOs is still in its early stages, with a lack of theoretical and empirical analysis having been conducted (DuPont, 2023a). Recent research on DAOs is based on classifications (Wang, Q. et al., 2023), architecture (Qin et al., 2022), and power concentration (Barbereau, Smethurst, Papageorgiou, Sedlmeir, & Fridgen, 2023). Specifically, a growing body of literature is emerging about DAO governance regarding governance mechanisms (Qin et al., 2022), machine (Wang, S. et al., 2019) and social governance (Nabben, 2023), voting mechanisms (Fan, Zhang, Wang, & Imran, 2023) or governance issues (Ding et al., 2022). However, the existing literature is dispersed and does not address DAO governance in an integrative way.

Despite the growing interest in DAO governance from academics and practitioners, there is a lack of conceptual and theoretical understanding of the main concepts that explain the governance of DAOs and the main impact and transformations for organizations, businesses, and online communities. We conducted an integrative literature review to understand DAO governance.

We have organized the review into three major parts. In the first part, we discuss the primary mechanisms of DAO governance. To achieve this, we analyze the literature on DAO technical, governance and organizational research. Secondly, we explore the DAO governance process, actors, and typologies. In the third part, we identify and explain DAO governance challenges and connect them with the Polycentric governance theory to highlight future research streams. Finally, we conclude with some reflections on DAO governance and its implications.

2. METHODOLOGY

This research proposes an integrative literature review. Our goal is to analyze and synthesize the academic literature regarding DAO governance following Torraco (2005). We run searches in scientific databases, including Web of Science, Scopus and Google Scholar. We selected the following keywords: Blockchain, DAO, DAO governance, smart contracts, and tokens. We selected relevant articles from 2010 to 2024 in scientific journals included conference papers, proceedings, books, DAO whitepapers, and governance proposals to understand better and guide our research. We analyze the first sample, screening the papers based on titles and abstracts to determine if the content is relevant to DAO governance. This search ends up with 181 papers. In the second step, our goal was to select publications that respond to our research, which consisted of understand and analyze DAO governance concepts, challenges, and theories. We adopt two main criteria for literature selection and evaluation: first, we choose literature that explains DAO governance concepts, procedures, principles, and challenges. Second, theoretical contributions that provide solutions to DAO governance challenges. Based on this criterion, we ended up with 57 papers. In the third step, we follow an integrative approach to codify documents into concepts and challenges. The fourth step is based on creating a set of aggregated topics by which we could classify the existing literature on DAO governance. The result of

mapping the literature helps identify DAO governance mechanisms and procedures, actors, typologies, challenges. Finally, we use the lens of the Polycentric governance theory to confront these challenges.

3. DAO GOVERNANCE MECHANISMS

The first outcome of the literature study and analysis DAO governance mechanisms and procedures. We introduce the concepts of smart contracts, digital forums, governance tokens, voting mechanisms, and digital common pool of resources.

3.1. Smart contracts

The development of smart contracts is the main technological element that enables DAO to be a novel form of governance and organizing (Buterin, 2014). Szabo was the first to introduce the concept of smart contracts as a computerized transaction protocol that executes the terms of contracts on the internet (Szabo, 1994). Ethereum moves Szabo's smart contract idea forward by providing a programming environment for deploying predefine rules (smart contracts) in a blockchain protocol (Buterin, 2014). The basic idea of blockchain smart contract systems, like Ethereum, is that developers can embed the terms of a contract and the parts involved in the contract using automated rules that execute and enforce when certain criteria are met (Wright & De Filippi, 2015). Ethereum, Cosmos, or Polkadot enabled the combination of smart contracts for developing DAOs (De Filippi & Hassan, 2020).

DAOs use smart contracts to encode automated or partially automated governance, management, and functioning rules (Wang, S. et al., 2019). Smart contracts serve organizational purposes such as task allocation and distribution (Hsieh & Vergne, 2023), online voting (Fan, Zhang, Wang, & Imran, 2023) and resource allocation (Jentzsch, 2016), setting complex governance, and organizational and operational rules (Wang, S. et al., 2019). Smart contracts provide DAO token holders with clear interaction, cooperation, and collaboration rules, enabling DAO communities to run through shared rules, objectives, boundaries, and sanctions (Rozas, Tenorio-Fornés, Díaz-Molina, & Hassan, 2018). Smart contracts are also used to define token holders' rights and practices by defining ownership, distribution of voting rights, transactions, and exchanges in a trustless digital environment (Barbereau, Smethurst, Papageorgiou, Sedlmeir, & Fridgen, 2023). Therefore, using smart contracts enables DAOs to expand automatization and scalability in online communities (Ellinger, Gregory, Mini, Widjaja, & Henfridsson, 2023). The main challenge with smart contracts is solving ex-post events and disputes not contemplated in the initial codification of smart contracts (Halaburda, Levina, & Semi, 2024).

3.2. Digital forums

Digital forums are online platforms that follow democratic rules and token holders' direct participation for self-governance (DuPont, 2018). Digital forums serve contributors to create proposals and discuss, deliberate, and vote on the project's future development (Ellinger, Mini, Gregory, & Dietz, 2023). In digital forums, token holders engage in discussions related to DAO governance changes, managerial and operational decisions, resource allocation and smart contracts development (DuPont, 2018). Digital forums have two main characteristics: First, token holders are encouraged to actively participate through voluntary contributions

following proposals, open communications channels, and votes (Ellinger, Gregory, Mini, Widjaja, & Henfridsson, 2023). Second, Forums are designed as open information systems for managing proposals, discussions, votes, ownership distribution, and participation to build trust among contributors and promote network participation (Ziegler & DuPont, 2023). DAO information systems also enable data extraction to explore the use of predictive models in DAO governance (Ding et al., 2022).

3.3. Governance tokens

The second main element we analyze from DAO governance is governance tokens. DAOs created their governance token for power distribution, funding, and voting (Bellavitis, Fisch, & Momtaz, 2023). Governance tokens unified ownership and management rights of DAO token holders (Qin et al., 2022). Governance tokens have three main characteristics: First, from an organizational perspective, governance tokens serve for power distribution among token holders in the DAO. Second, Governance tokens are used to measure the voting power of each token holder during votes (Fan, Zhang, Wang, & Imran, 2023). Third, from a market perspective, governance tokens are tradeable digital assets on the crypto market, and their value depends on the performance of the DAO over time (Barbereau, Smethurst, Papageorgiou, Sedlmeir, & Fridgen, 2023). Governance tokens are the only requirement for voting in a DAO, representing a low barrier to entry (Qin et al., 2022). The main challenge of DAO governance tokens is the risk of plutocracy and the volatility of crypto markets (Ziegler & DuPont, 2023).

3.4. Voting mechanisms

The third main element we explore in DAO governance is voting mechanisms. Voting mechanisms serve DAOs for community decision-making through online voting (Bellavitis, Fisch, & Momtaz, 2023). Voting mechanisms have three essential characteristics: First, the voting mechanism grants token holders permission to vote or delegate votes on DAO governance proposals. Second, the voting mechanism defines the majority required to pass or reject a governance proposal, typically set at 51%, but the percentage can vary depending on the type of DAO. Third, voting mechanisms also establish the quorum required in each vote, which means the minimum number of token holders needed to make the vote valid. The quorum also changes depending on the type of DAO (Bellavitis, Fisch, & Momtaz, 2023). DAOs employ diverse voting mechanisms such as ragequitting, quadratic, weight voting, holographic, or liquid democracy (Fan, Zhang, Wang, & Imran, 2023). However, the design of the voting mechanism based on majority and quorum rules makes DAO vulnerable to network collusion regarding specific governance and managerial decisions (Qin et al., 2022).

3.5. Digital common pool of resources

DAOs use a digital common pool of resources to experiment with power distribution and resource allocation (Jentzsch, 2016) and solve collective action problems (Soleimani, Bhuptani, Young, Haber, & Sethuram, 2019). The digital common pool of resources is a digital adaption of a common pool of resources introduced by Elinor Ostrom in her work "Governing the Commons" (Ostrom, 1990). DAO management of a digital common pool of resources is built around decentralized control, consensus building and community decision-making (DuPont, 2023a). DAO's digital common pool of resources represents the treasury of the organization.

DAO treasury comprises assets that can acquire different forms, such as cryptocurrencies, stablecoins, governance tokens or non-fungible tokens (Bellavitis, Fisch, & Momtaz, 2023). DAO treasury can be used for different purposes: The treasury can be used for trading in crypto markets or using staking procedures (Ziegler & Welpe, 2022). The treasury serves to fund projects that develop blockchain solutions that pursue the purposes and goals of the DAO (Ziegler & DuPont, 2023). The main challenge of DAO digital common pool of resources is controlling projects performance and accountability after being funded (Beck, Müller-Bloch, & King, 2018), the risk management of DAO assets considering the volatility of crypto markets (Ziegler & Welpe, 2022) and align short/long-term token holder's incentives (Ellinger, Gregory, Mini, Widjaja, & Henfridsson, 2023).

4. DAO GOVERNANCE PROCESS, ACTORS, AND TYPOLOGIES

The second outcome of the literature study and analysis DAO governance process, actors, and typologies.

4.1. DAO Governance process

Most DAOs have developed a governance process based on self-governance and organization through collective action and community decision-making (DuPont, 2023a). DAOs have established and standardize a governance process Figure 1 based on open membership for creating proposals, discussions, deliberations, and token ownership for voting (Ziegler & Welpe, 2022):

1. DAO governance process begins with token holders producing proposals and opening discussions in a digital forum for deliberation and network feedback.
2. After deliberation, the contributor submits the proposal to editors. Editors filter proposals to ensure they follow the governance rules, process, and the correct form. This process is public, so accessibility is open. Also, the editors review is open, and it can be controlled by the network.
3. Once the editors accept the proposal, the proposal is co-joined with other proposals passed by Editors to be voted on a predetermined date. Token holders receive communications through forums and social networks to participate in the vote using its governance tokens.
4. If the proposal receives the majority and quorum required and passes, it is executed automatically through smart contracts or manually by DAO members.

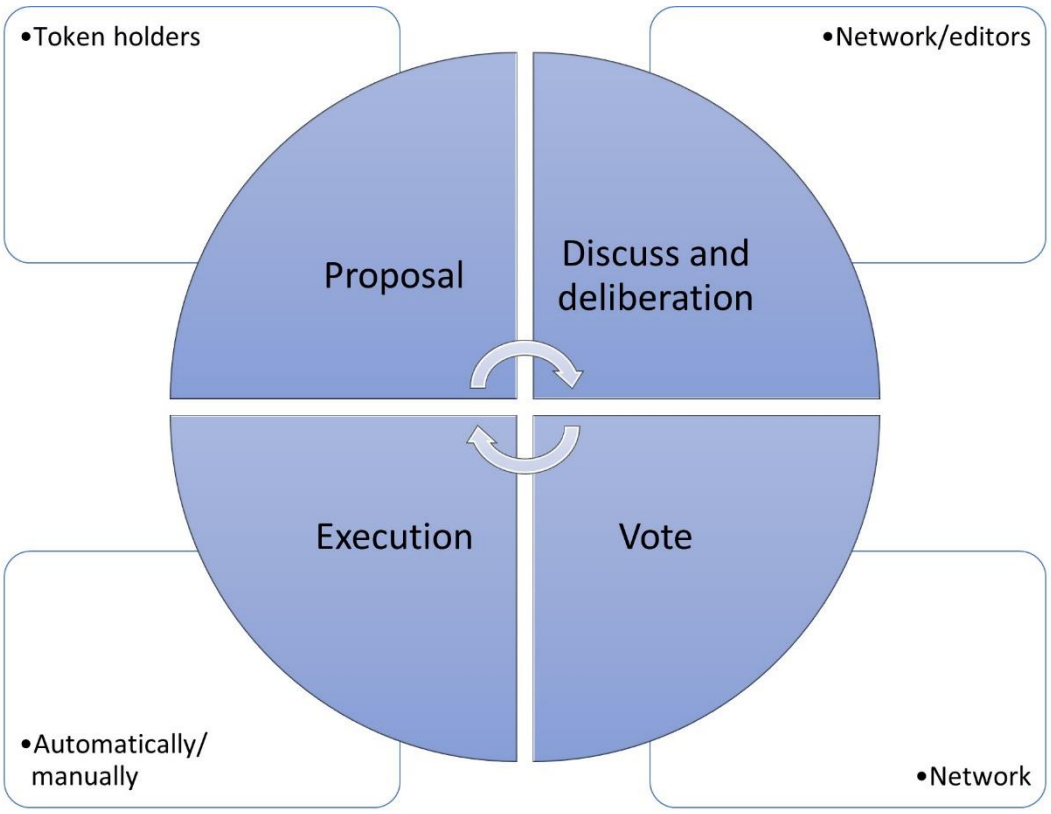

Figure 1.- DAO Governance Process

The main challenges regarding the DAO governance process are the high cost of proposals (Qin et al., 2022), voter apathy (Augustin, Eckhardt, & de Jong, 2023) and low approval rates of proposals (Fan, Zhang, Wang, & Imran, 2023). DAOs are experimenting with a delegation of voting powers to delegators or experts (liquid democracy) or the use of predictive markets to capture the attention of token holders on relevant proposals and votes (holographic) (Fan, Zhang, Wang, & Imran, 2023) for improving network participation (Ziegler & DuPont, 2023)

4.2. DAO actors

Polycentric governance refers to a governance system built upon diverse centers of authority and decision-making based on network cooperation, collaboration, and common governance rules (McGinnis, 2016). These governance systems enable communities to achieve collection action and pursue common goals using governance mechanisms and processes instead of hierarchies and markets (Ellinger, Gregory, Mini, Widjaja, & Henfridsson, 2023). Three dimensions explain Polycentric governance functioning: First, polycentric governance enables diverse actors from multiple decision-making centers to cooperate and collaborate to achieve collective action. Second, these actors interact through mutual adjustment, enabling clear rules of cooperation, interaction, sanctioning and monitoring. Third, Polycentric governance systems enable emergent governance system that captures economies of scale from different centers of authority (Patala, Albareda, & Halme, 2022). According to recent DAO governance research, DAOs can be seen as Polycentric governance systems composed of diverse actors and multiple centers of authority and decision-making (DuPont, 2023a; DuPont, 2023b; Ellinger, Gregory, Mini, Widjaja, & Henfridsson, 2023).

Since its inception, DAOs have involved various actors performing different tasks and roles without any central authority Figure 2. DAOs are networks composed of founders, developers, and investors. The founders are the ones who released the DAO whitepaper, which explains the purpose, governance, funding, objectives, and investment information of the project. The whitepapers are shared with communities of crypto investors and users using social networks and forums to attract token holders. Developers are responsible for encoding the governance and management rules using smart contracts. Investors are the ones who invest in DAOs using cryptocurrencies in exchange for governance tokens (Santana & Albareda, 2022). As we explained before, these governance tokens enable them to participate in the governance and management of the DAO (DuPont, 2019)

In the last years, DAOs have also adopted Foundations which are non-profit organizations responsible for safeguarding and managing the funds raised by the founders and held in the digital common pool of resources. These Foundations are conforming by co-founders and core developers of the DAO. Foundations uphold the whitepaper principles and values, promote strategies for achieving DAO objectives and goals, and drive community strategies. They are also actively involved in the governance process by overseeing the governance proposals of token holders as Editors (Ellinger, Mini, Gregory, & Dietz, 2023).

DAOs are experimenting with incorporating other actors and roles into their networks to confront governance challenges. For example, Editors supervise token holders' proposals to ensure that they follow the governance processes and rules (Light, 2018). In the case of Optimism or Lido, both projects create a Bicameral system of governance tokens making a distinction between citizens and token holders. While citizens have the function to control the Foundation or veto decisions regarding changing the original governance rules of the DAO, the token holders are focused on allocating resources of the digital common pool of resources (System, 2022). We also see DAOs experimenting with the creation of guilds or working groups with specific task normally connected with operations and day to day managerial tasks of the DAO like in the case of CityDAO. Other DAOs like Aragon or Arbitrium use delegators if token holders want to give their voting power to others with more experience and knowledge; this right can be revoked at any time (Izquierdo, 2019).

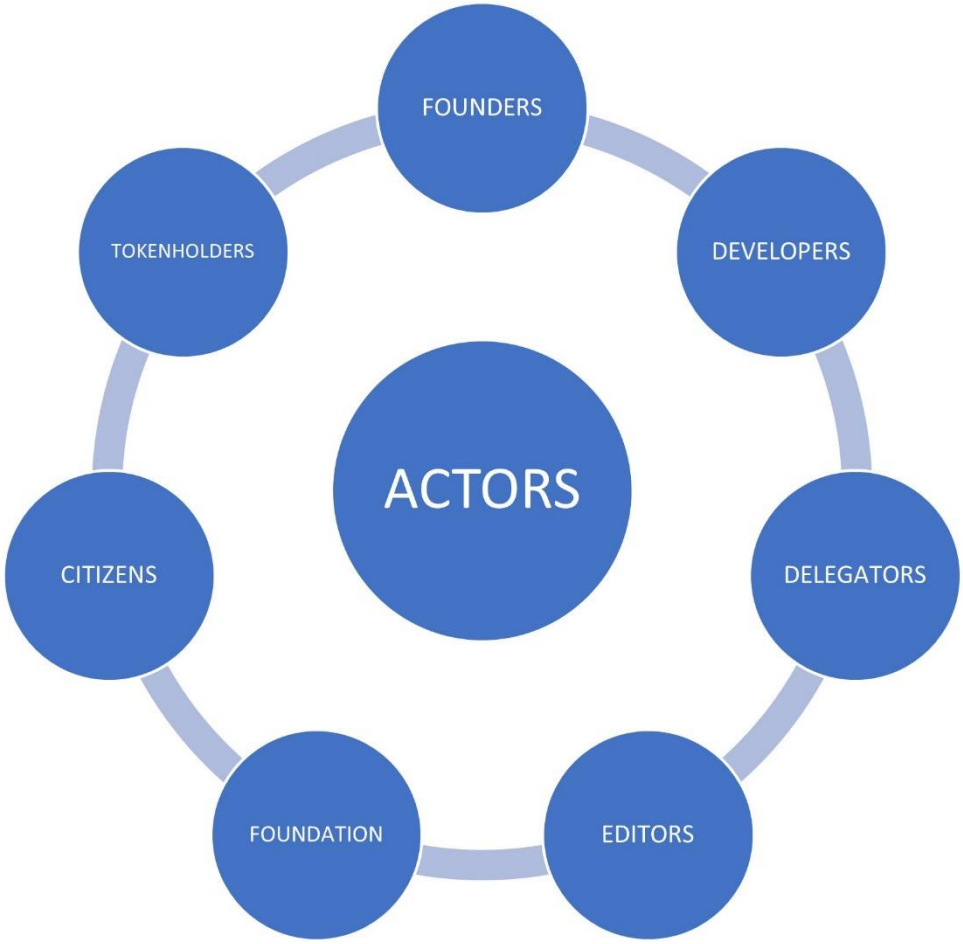

Figure 2.- DAO Actors

4.3. DAO Typologies

We classified DAOs into three main categories based on their blockchain-based products and services, the level of automatization and community-driven approach, and the emergence of new authorities.

Firstly, DAOs can be classified based on the blockchain-based products and services they offer. There are four main clusters: venture capitalist, layer 2 solutions, DAO platform, and Defi protocols. For example, MolochDAO and DAOhauss have contributed significantly as venture capitalist funds for developing the Ethereum ecosystem. Similarly, Optimism and Arbitrium have been instrumental in working on layer 2 solutions to address the issue of high gas prices on the Ethereum blockchain. Aragon, Colony, and DAOhaus are blockchain platforms that facilitate the creation and development of DAOs. The last group is considered Defi protocols, so they offer financial services; for example, Uniswap, Bisq, and 1inch are decentralized exchanges allowing token and crypto swaps. AAVE and MakerDAO are lending protocols, and Dydx is a decentralized exchange for crypto derivatives (Wang, Q. et al., 2023).

Secondly, DAOs can be divided into two categories based on projects more focused on automatization or others with a more community-driven approach. The first category includes DAOs such as MolochDAO, Bisq, or DAOhaus, which are focused on automating DAO rules, tasks, and processes as much as possible, even erasing the need for human intervention to increase efficiency in governance and managerial processes

(Nabben, 2023). The second category includes DAOs such as Arbitrum, Optimism, or Colony, which are more community-oriented, fostering a sense of inclusivity and participation. In these cases, the governance conversation of their token holders revolves around proposals, network participation, and the development of new voting mechanisms (Ziegler & Welpe, 2022).

Lastly, DAOs can also be classified based on the emergence of new authorities and novel actors in the absence of any central authority. We identified DAOs which follow the original idea inseminated by "The DAO," creating decentralized networks of investors and developers. Examples of this type of DAOs are MolochDAO, Bisq, and DAOhaus. Other DAOs are introducing new authorities like Foundations to confront governance and management challenges. Examples of this type of DAOs are Aragon, Colony, Dydx, or Uniswap. We also see DAOs experimenting with the emergence of novel actors like citizens or delegators, changing their governance tasks and structures. Examples of these DAOs are Optimism and Arbitrium.

5. DISCUSSION

DAOs are online communities experimenting with blockchain-based governance mechanisms and processes to create democratic organizations for collective action while developing blockchain-based products and services. Our literature review identified that DAO governance enables online communities to codify design principles regarding organizational governance and management rules, ownership and voting rights using smart contracts, voting mechanisms and a common pool of resources. DAO contributors decide the organization's future development using democratic rules and direct governance participation processes. This is done using digital forums for opening proposals and discussions and governance tokens for voting. In our review, we identified different challenges in DAO governance. We focus on three main DAO governance challenges we identified in our literature review: 1) *Decision-making problems for DAO management and operations decisions* refer to the problem that DAOs deal with day-to-day operations, managerial activities, governance processes and task division and allocation using its decentralized governance model. 2) *DAO network collusion for sabotaging DAO treasury resource allocation decisions* refers to the problem that appeared in DAOs because all governance and managerial decisions require network votes and consensus, which on occasion may lead to network collusion or groups sabotaging decisions of how to spend the DAO treasury into projects and investments 3) *the high cost of governance proposals and low network participation in discussions and votes* refers to the problem that arises due to DAO open and democratic governance design.

We propose using the Polycentric governance theory and its main dimensions to address these challenges Table 1. First, we suggest analyzing DAO working groups or guilds and studying if they are becoming emerging centers of authority in DAOs; it's also important to explore its managerial and operational processes, goals and tasks, and how they deal with decision-making problems. Examples of emerging centers of authority might be in the form of guilds or work groups. Considering the DAO governance ethos, it is also important to explore how DAO network contributors evaluate and control these emerging centers of authority. Second, we propose studying and analyzing how DAOs develop mutual adjustment mechanisms for defining clear cooperation, interaction, and decision-making rules between different emerging centers of authority. Regarding mutual

adjustments, further research is needed to understand governance tokens' expansion into bicameral governance systems that separate DAO governance decisions from management and operation decisions to confront DAO network collusion for resource allocation decisions. Finally, we propose to study and analyze knowledge transfer between emerging centers of authority in the governance and management of the DAO. Regarding this, it is important to understand how they use DAO information systems to select and prioritize information regarding governance proposals, discussions and votes to achieve economies of scale and confront the high cost of producing governance proposals and the low network participation.

DAO GOVERNANCE CHALLENGES	POLYCENTRIC GOVERNANCE DIMENSIONS
Network Collusion for sabotating DAO Treasury Resource allocation	Mutual adjustment for Clear Rules of Cooperation, collaboration and Decision-Making
Decision Making Problems for DAO Management and Operations Decisions	Emerging Centres of Authority for Decision-Making
High Costs of Governance Proposals and Low Network Participation in Governance Processes	Knowledge Transfer Between Different Centers of Authority for Economies os Scale

Table 1.- Link between DAO governance challengues and Polycentric governance dimensions

6. CONCLUSION

This paper builds an integrative literature review on DAO governance to understand its main transformations. We have studied DAO governance as a new form of governing online communities for organizational, managerial and information systems studies. The literature lets us explain DAO governance mechanisms, procedures, actors, typologies and challenges. We identified and explained DAO governance challenges and connects them with the Polycentric governance theory opening future research streams about DAO governance. New research must be built on DAO governance from theoretical and empirical perspectives to confront actual and future challenges.

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