Decentralized Autonomous Organizations: Organizational Opportunities and Governance Challenges

Olivier Rikken, Marijn Janssen, and Zenlin Kwee

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Abstract

Decentralized Autonomous Organizations (DAOs) are one of the most advanced blockchain-based applications, posing many opportunities for new governance models and organizational forms. Over the past decade, the number of DAOs and their assets under management have grown exponentially. DAOs offer many opportunities and advantages for organizations, including internal organizational democratization, external actor participation, transparency, advanced auditability, autonomy and automation of business processes and decisions, higher efficiency, lower cost, increased trust, and new organizational and governance forms. DAOs are being used for a wide range of business purposes, and their various

O. Rikken (✉) · M. Janssen
Technical University of DelftTechnical University of Delft, Delft, Netherlands
e-mail: o.k.rikken@tudelft.nl; M.F.W.H.A.Janssen@tudelft.nl

Z. Kwee
Delft University of Technology (TU Delft), Delft, Netherlands
e-mail: Z.Roosenboom-Kwee@tudelft.nl

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governance elements and choices that can be made provide significant flexibility in their deployment. Although there are many opportunities, DAOs can face multiple (governance) challenges as well. As there are many differences between DAOs as a result of the various choices, one cannot approach a DAO as one organizational form. The choices in governance setup, business purpose, and even the chosen infrastructure can influence the long-term viability and should be made carefully.

Keywords

Decentralized Autonomous Organizations (DAOs) · Governance · Business Opportunities

1 Introduction

Blockchain is a technology that provides for a public electronic transaction record of integrity without the need for a central authority for integrity guarding. This means that entities can set up and run a public and open-for-participation administration. Participants can trust the integrity of the content. A network of computers (nodes) can take over the task of central authority for integrity guarding by use of consensus mechanisms or algorithms and cryptography (Mainelli & Smith, 2015; Nakamoto, 2008; Rikken et al., 2024).

Blockchain technology roots go back to the mid-nineties when Haber and Stornetta introduced the concept through their work on the timestamping of digital documents (Haber & Stornetta, 1991). Yet, the technology's generally accepted inception occurred in 2008 with the publication of the Bitcoin whitepaper (Nakamoto, 2008) and the subsequent introduction of the Bitcoin network in 2009. This first worldwide implementation of the technology entailed the introduction of an alternative, peer-to-peer transfer of value (electronic cash) system, where the need for trusted third parties like (central) banks for the transfer of value proved to become obsolete.

Key blockchain characteristics are decentralization, transparency, and immutability, and their combination also results in clear provenance or audit trails (traceability of transactions) (Ali et al., 2021; Frizzo-Barker et al., 2020). These characteristics made it possible to re-imagine products, services, and even organizational forms and information sharing, logic execution, and transfer of value in any value chain. This reimagination occurred because it was no longer necessary for reliance on trusted third parties or central authorities to safeguard the data storage and execution of coded rules in a shared digital environment.

The first generation of blockchain technology, by means of networks like Bitcoin, Litecoin, and Doge, primarily focused on the transfer of value or immutable storage of data. The second generation of blockchain technology emerged around 2015 through the rise of networks like Ethereum and Hyperledger, which brought crucial

additional functionality known as "smart contracts" in Ethereum (Buterin et al., 2014) or "chaincode" in Hyperledger (Cachin, 2016). These smart contracts create the possibility not only to store data on a blockchain network but also to create programmable accounts that host coded, deterministic rules. These rules are executed automatically when triggered by a specific incoming transaction or message (Qin et al., 2021; Rikken et al., 2018; Sturm et al., 2019; Zheng et al., 2020). These smart contracts form the basis of decentralized applications or dApps (Antonopoulos & Wood, 2018; Raval, 2016).

Over the past few years, blockchain technology applications have risen significantly. Initially with the introduction of Bitcoin, the primary focus of products and services was predominantly on financial-based products and resulted for a significant part in the form of the Decentralized Finance (DeFI) industry (Al-Megren et al., 2018; Mohanta et al., 2018; Rikken et al., 2019). Since then, the products and services offered have expanded to a very wide range, from digital identities, voting systems, healthcare solutions, data (also called oracle) services, and other related applications that emphasize secure and verifiable evidence trails without a primary focus on transaction of value (Al-Megren et al., 2018; Arnaucube & Baig, 2022; Berdik et al., 2021; Jing et al., 2021; Mohanta et al., 2018; Zhang et al., 2018).

One of the most advanced products and services based on (a collection of) smart contracts is the creation of a *Decentralized Autonomous Organization* (DAO), which represents a potential new organizational form and new governance model for web-based collaboration based on Web3 technology (Dwivedi et al., 2022; Hassan & De Filippi, 2021; Rikken et al., 2023b). Although DAOs are seen as providing endless new possibilities, they remain relatively misunderstood. In this chapter, we delve into DAOs to clarify what DAOs are, explore their applications, distinguish diverse types (of governance) of DAOs, and assess their business opportunities and risks.

In this chapter, we first describe what constitutes a DAO by elaborating on decentralization and autonomy and subsequently deriving a definition. Next, we discuss the business purposes of DAOs in practice and the benefits they offer. We then examine various DAO implementation and deployment methods and elements. Subsequently, we deep dive into the governance of DAOs, discussing various governance elements and set-up possibilities. We also then explore the governance risks and challenges associated with using DAOs. We then consider future developments and identify potential drivers and hurdles for the wider adoption of DAOs in business. Finally, we draw various conclusions for DAOs in business.

2 What Constitutes a DAO-Decentralization and Autonomous Explained

DAOs have gained significant traction and attention over the years. The concept was first introduced by Daniel Larimer in 2013 as Decentralized Autonomous Corporations (DAC), as blockchain-based organizations co-owned and jointly managed with

a profit focus, where cryptocurrency ownership represented the shares and company bylaws were coded (Larimer, 2013). This concept was later further explored by Vitalik Buterin, who expanded the possibilities of DACs beyond strictly for-profit entities and coined the term Decentralized Autonomous Organization. He furthermore explored what a DAO is by emphasizing what it is not, namely, it is neither a fully automated agent (or artificial intelligence (AI)) nor merely a Decentralized Organization (DO). He acknowledged that the line between a DO (where all decisions are made by human participants) and a DAO is thin, noting that a DAO has a (somewhat) higher level of automation or autonomy than a DO. Eventually, he defines a DAO as having humans at the edges and automation at the center (Buterin, 2014).

Ever since the first description of DAOs, the number of "perceived DAOs" has risen exponentially, as displayed in Fig. 1, which highlights the growing interest in DAOs over recent years.

The term "perceived DAOs" is chosen deliberately, as there is an ongoing debate on what exactly constitutes a DAO, which we will elaborate on later in this section. Not only has the number of perceived DAO projects risen exponentially, but the assets under the management of DAOs have also grown fast. According to DAO tracking site deepDAO.io, the cumulative amount of value in the treasuries of the DAOs they track (approximately 50,800 DAOs in January 2025) has grown from approximately $363 million in December 2020 to $37.6 billion in December 2024. These statistics show even faster growth in assets than in the number of DAOs. That is, there is approximately a 60-fold increase in the number of DAOs versus a 100-fold increase in assets under management.

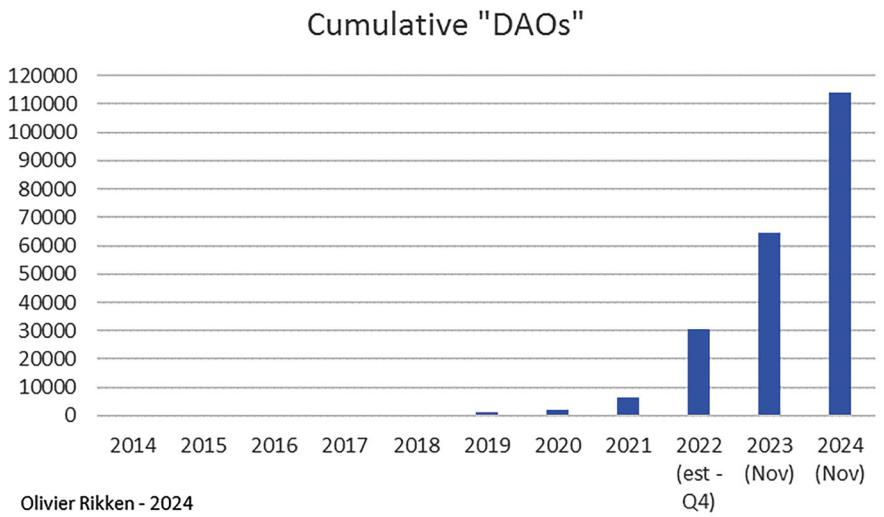

Fig. 1 Number of perceived cumulative DAO projects 2014–2024

2.1 Defining DAOs

The definition of DAOs is much debated, dating back to Buterin's article on DAOs in 2014 (Buterin, 2014). Therefore, we will start by dissecting the term DAO, focusing on its two core elements: decentralization and autonomy.

The first element in a DAO is **decentralization**. This can be regarded on two levels. First, decentralization on the infrastructure level, being that DAOs are being implemented on blockchain-based infrastructures. Dupont (2017) describes DAOs as organizations run on a blockchain using smart contracts. Similarly, Kypriotaki et al. (2015) and Kondova and Barba (2019) emphasize that DAOs are entities that use blockchain to autonomously and decentralize run their operations. The second level is the organization (embedded in the code of the DAO application). Hsieh et al. (2018) emphasize that DAOs are organizations that operate with democratic processes. Hassan and De Filippi (2021) point out that there is no central control and DAOs adhere to decentralized governance. Bellavitis et al. (2022) describe them as collectively owned and managed organizations. We conclude that, with regard to decentralization, *from an organizational perspective, DAOs can thus partially be described as blockchain-based organizations where decision-making can be done in a decentralized way.*

The second element is **autonomy**. Here, there are some scholars who take a more philosophical approach by arguing that autonomy refers to DAOs can operate autonomously, meaning without interference from external controls or central internal controls (Green, 2024). But most describe the autonomy elements as a form of automation. Either as code executed or rules enforced by a blockchain infrastructure (El Faqir et al., 2020; Hassan & De Filippi, 2021; Honigman, 2019) or more specifically that the enforcement of the rules is performed by smart contract (Bellavitis et al., 2022; DuPont, 2017; Jentzsch, 2016; Rikken et al., 2019; Wang et al., 2019).

Although named autonomous, as already stated by Buterin in 2014, DAOs should not be seen as fully autonomous or AI agents (Buterin, 2014). Certain actions are autonomously executed by code, often encoded in a smart contract, after being triggered by an incoming transaction or message. The decisions regarding the autonomous execution may be fully pre-coded. These may be called a deterministic coded decision, which is a predefined coded decision tree of "if-this-then-that" statements. This pre-coded reaction occurs from information accompanying the incoming transaction or message. If the reaction is not pre-coded, then it may be the result of voting by humans—through the notary function. It would be based on the outcome of the human voting—registered in the DAO notary function. This result will be autonomously executed according to the outcome of the vote. With regard to autonomy, we conclude that *DAOs can thus also partially be described as organizations where decisions are autonomously executed, predominantly by means of smart contract code on blockchain-based or decentralized infrastructures.*

Besides the technical element of decentralization and autonomy, Rikken et al. (2023b) empirically analyzed over 1600 DOAs on common functionalities that all of these DAOs had and found that the overwhelming majority of these DAOs have two

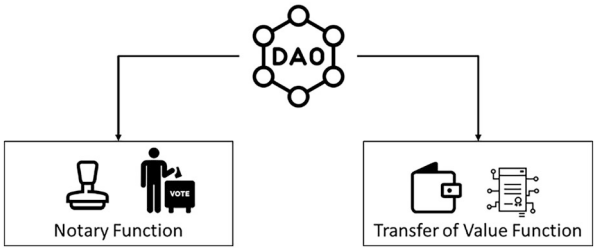

Fig. 2 Most common DAO functionalities, based on Rikken, Janssen, Kwee (2023b)

common functionalities: a **notary (trusted) function** and a **transfer of value** function (Fig. 2).

The **notary function** entails the possibility to organize, guard, execute, and archive trusted voting within DAOs. This means that a decision up for voting can be created, and it is monitored if the voting goes according to a series of rules. These rules include: is someone eligible to vote, how much voting power does the participant have, did the participant already vote, is the voting still open yes or no, and so on.

The vote autonomously executes according to the voting outcome. The vote is then archived on the blockchain infrastructure. All these trust rules are executed by smart contracts without the need of a person or department to guard the integrity of the voting and the surrounding processes. Voting balances are being tracked through the possession of *governance tokens*. Governance tokens can transparently track the voting power of a participant. These tokens are registered on accounts with account numbers. Tokens registered on a certain account number on any blockchain infrastructure can be seen broadly, but there is no transparency on who is behind an account number. Votes can be on any topic, from appointing (new or existing) governance tokens to new or other accounts to internal polls to decisions on the transfer of value out of the DAO.

The second common function within DAOs, the transfer of value function, is basically the treasury function of the DAO. Crypto assets, such as cryptocurrency (the native token of a certain blockchain infrastructure like Ether or bitcoin) or tokens (other tokenized representations of value other than cryptocurrencies) can be stored in a treasury or transfer of value functionality of a DAO. This storage can occur as long as that crypto asset exists on the underlying infrastructure. For example the treasury cannot store bitcoin on an Ethereum based DAO, as bitcoin is exclusive for the Bitcoin blockchain. Within any DAO, it is easy to send any form of crypto asset if that asset exists on that particular network into that DAO. It is up to a DAO participant to propose to extract value from the asset through a transaction. If approved, smart contracts will autonomously execute the transfer of value function. We therefor conclude that from a functional perspective, *DAOs can be described as organization that at least have a notary function and a transfer of value function.*

Based on the conclusions on decentralization, autonomy, and functionality as laid out above and taking into account earlier definitions of DAOs by other scholars, in previous research, we created a comprehensive definition of DAOs, being:

> A DAO is a system in which storage and transaction of value and notary (voting) functions can be designed, organized, recorded, and archived and where data and actions are recorded and autonomously executed in a decentralized way. (Rikken et al., 2023b, pp. 7–8)

Using this definition, the number of actual DAO projects is not as large as most statistics show. A considerable number of the perceived DAOs do not adhere to all four elements—decentralized, autonomous, including notary function, and a transfer of value function. These entities would be referred to as DINO (DAO in Name Only). The element of autonomy seems to be lacking in many of these DINO-DAO projects. DAOS that use platforms such as Snapshot,[1] for example, lack autonomous execution of decisions or incoming messages, leading to centralization risks that have been materialized in the past, can be debated to be more DOs than DAOs (Rikken et al. 2023b). There is some scientific debate on this view and issue (van Vulpen et al., 2024b).

DAOs represent a broad amount of organization and purposes. DAOs cannot be approached as one type of organization, as will be elaborated on in this chapter. We will start with the business objectives of DAOs and the business benefits of using DAOs.

3 DAO Use Cases and Business Purposes

Although DAOs are often perceived as one organizational form, there is an extremely wide variety of DAOs. The variety can be due to business purpose, DAO initiation, deployment perspective or from a governance perspective, or mixture of these characteristics. In this section, we will elaborate on the business objectives and benefits for businesses using DAOs.

DAOs, as stated earlier, were originally envisioned for setting up corporations where cryptocurrency represented the shares of the company as well as the means of payment of the company (Larimer, 2013). Although envisioned by others to serve more purposes or organizational structures than corporations (Buterin, 2014; Kypriotaki et al., 2015; Morrison et al., 2020).

The first implementations were predominately financial services focused, driven by the "Decentralized Finance" (DeFi) industry. Exemplary initiatives include Bisq, Dash, makerDAO, and theDAO from the early period of 2014–2016. Bisq is a decentralized exchange (Hickey & Harrigan, 2022). Dash was a fork from the bitcoin protocol providing payment and project funding claiming to be the first true DAO as of 2014 (Bitcoinist, 2016). makerDAO is the DAO behind the

[1] https://snapshot.box

stablecoin DAI (Brennecke et al., 2022). The most notorious, theDAO, was an decentralized investment fund (DuPont, 2017; Falkon, 2017). All these DAOs were active in DeFi activities, focusing on tokenization, new ways of investment, and ownership.

DAOs really gained attention to the wider audience as a result of "theDAO" hack. In this notorious incident, the code of this DAO was misused. This misuse made it possible to drain funds from that DAO with the governance of the DAO themselves having limited intervention power. This event revealed the challenge for unprecedented dependencies to other governance structures (Dhillon et al., 2017; DuPont, 2017; Falkon, 2017; Rikken et al., 2019). This challenge set will be elaborated on further in this chapter in Sect. 8. Since this inception, DAOs, as shown in Fig. 1, have shown exponential growth, both in numbers and in managed assets.

While the original focus of DAOs was on DeFi, with the growth in the number of DAOs as result of the user-friendly possibilities in DAO development, the number of use cases for DAOs also grew steadily, as will be discussed later in this chapter. Currently, DAOs have countless uses and business objectives. Various scholars created DAO objective categorizations (Ding et al., 2023; Harmony, 2022; Hennekes, 2022; Stelzner, 2022).

Based on these various categorization attempts, Rikken et al. (2024) have categorized the possible business objectives for DAOs into eight main categories: economic, social, research and development, human, national, global utilities, art, and others. An overview of these categories, general aim per category, description, and various subcategories per main business objective category are displayed in Table 1.

Although there are eight categories, the majority of DAOs have an economic (DeFi), research and development, social, and global utilities (infrastructure) objective (Rikken et al., 2024).

4 DAO Business Opportunities and Benefits

The usage of DAOs does pose various business opportunities and benefits. The foremost benefit is that it creates the **opportunity for democratization within an organization**. By voting through the notary function, participants can jointly make decisions within DAOs, enabling true employee participation. This inclusion opens doors for **full democratization** within organizations but also over organizations and enabling public-private corporations and **external stakeholder** (e.g., citizen) **participation** (Rikken et al., 2022) among other forms.

Additionally, coded rules lead to the possibility of **programmability of a wide range of business processes** (Samman & Freuden, 2020; Wang et al., 2019). This autonomous execution of decisions, a key element of DAOs, can lead to **higher efficiency** within organizations and thus **lower costs** on collaboration and management. It can also lessen financial costs by the use of blockchain-based accounts and crypto assets (Appel & Grennan, 2023; Rikken et al., 2024; Wang et al., 2019; Wright, 2021).

Table 1 DAO business objective categorization. Retrieved from Rikken, Janssen, Kwee (2024, p. 112)

Business objective category	General aim	Description	DAOs business objectives as described in various sources
Economic	For-profit organizations	DAOs that aim to create a profit for their tokenholders in the form of cryptocurrencies, (liquidity pool) tokens and stablecoins	DeFi, Play2Earn, venture, investments, CCO, media, developer, work, service, co-ownership, product, protocol (dApp), peer-production
Social	Common/social goal without a profit goal	DAOs where the participants work together toward a common/social goal without a profit goal	Clubs, social, matching, hackathon, peer-production
Research and development	Collecting and sharing knowledge	DAOs that aim to collect funds and distribute it for research and development work for the common good-nonprofit	Grants, oracle
Human	General purposes nonprofit	DAOs where the primary goal is to give back to society of the collected funds	Charities, philanthropy, basic, impact
National	General utilities on a national level	Democratic decisions of political parties aimed to increase citizen participation and general use decentralized national notary functions	Political, restructuring basis of governance and democracy—General use or national notary functions
Global utilities	Global general utilities	DAOs that aim to set up and maintain global general utilities that are open to use for anyone like blockchain infrastructures and virtual worlds	Metaverses, infrastructure, protocol (infrastructure)
Art	Art creation, ownership and trading related business objective	DAOs that specifically aim at art (collective ownership, creation, management and distribution)	NFT platforms, art
Other	Other business objectives than the seven other categories	Either the DAO has combined business objectives cross-category or does not fit the other descriptions as they facilitate a too narrow function or single process	Web3 platforms (multiple business objectives, e.g., Lyngyo), sub, singe-purpose(e.g., constitution DAO), validator, collector, wallet (e.g., raid guild war chest), automating enforcement of ethical policies in business processes

Other DAO benefits are related to the inherent benefits of the decentralized, often blockchain-based, infrastructures they are built upon. The elements of **transparency, irreversibility, and permanence** are especially seen as key features (Berdik et al., 2021; Sas & Khairuddin, 2017). Within DAOs, all on-chain actions, on-chain versus off-chain will be further explained in Sect. 5, which are initiated and performed by transactions that are recorded and archived on the decentralized infrastructure. This recordkeeping creates transparency on all votes and transactions of value (in the form of crypto assets) to and from DAO accounts as one needs to send in a transaction in order to perform a vote or to initiate a transfer of value. These characteristics mean that all participants can see and trace the voting results and execution, as well as monitor all incoming and outgoing transactions of value and their associated triggers.

Transactions on a blockchain infrastructure are irreversible and permanent. This immutability means that no one can one-sidedly change or delete a transaction, which in itself creates true provenance and thus a very strong audit trail (A. Wright, 2020). All transactions are visible due to the use of the underlying blockchain infrastructure, but this visibility is only on an account level. This level of visibility means that an account number (public key) can be seen. The transaction request of the account number can be seen, including the data sent along with this transaction. But the entity behind this account number remains anonymous (not visible to the community). It is thus a transparent but pseudonymous transaction. There are certain initiatives where even the originating account number of origin of the transaction is hidden or obfuscated, adding to the preservation of privacy, but these are not implemented on scale yet (Arnaucube & Baig, 2022).

Although many DAOs do not represent new types of organizations per se and can be plotted within existing legal frameworks (Rikken et al., 2023), DAOs promise to create the opportunity for new organizational forms and types of governance (Morrison et al., 2020; Wang et al., 2019). Differences in governance will be elaborated on later in this chapter in Sect. 7. The tokenized character of governance of DAOs often also inherently provides for co-ownership and automatic profit sharing of the revenues of the DAO (Larimer, 2013; Wright, 2020). An overview of various business benefits by using DAOs are plotted below (Table 2).

Despite the potential benefits of DAOs, the vast growth of DAOs, and their possible business objectives, DAOs are not necessarily a silver bullet for each business objective (Hart, 2022; Ivanov, 2022). Not every business objective shows equal long-term viability chances. Especially non-economic DAOs—the seven categories other than economic DAO business objectives—tend to show better long-term viability than economic DAOs (Rikken et al., 2024).

5 How to Initiate a DAO

To set up a DAO requires an understanding that a DAO often partially exists in off-chain and partially in an on-chain environment. On-chain means actions are recorded and-or executed by a blockchain infrastructure, often by means of the use

Table 2 Overview business benefits DAOs

Benefits	Description
Organizational democratization	All participants in a DAO are eligible to vote on decisions
External participation	Besides DAO participant governance participation within a DAO, it creates the opportunity to actively involve external actors in a DAO as well, increasing external participation possibilities in organizations (e.g., citizen participation in participative budgeting DAOs)
Transparency	As result of the use of blockchain as underlying infrastructure, the actions of a DAO can be viewed by all users
Accountability	The ability to view transactions enables also external audits and accountability
Auditability	The irreversibility and permanence characteristics, together with the transparency, leads to very strong auditability of actions within DAOs
Autonomy and automation	By use of smart contracts, pre-programmed actions and decision outputs are autonomously executed
Higher efficiency	Autonomous execution of actions and decisions, as well as low-level decision-making can lead to higher efficiency in DAOs
Lower cost	Higher efficiency of DAOs in itself, combined with the open-source availability of additional products and services and the use of crypto assets, can lead to lower cost of operations
Trust	The combination of auditability and transparency, as well as the immutability of the coded rules in smart contract can increase trust in DAOs
New organizational and governance forms	DAOs pose an opportunity to create and experiment with new organizational forms with high participant involvement and new governance forms within organizations

of one or more smart contracts. This action also includes the transactions of individual tokenholders regarding voting to the notary function (often a separate smart contract) that then can be transparently traced. When certain outcomes are met, the notary smart contract can then autonomously send a message (a transaction from a smart contract account) to another smart contract. For example, a message to the treasury function smart contract that makes a transaction of value out of the treasury function smart contract account to another account.

But DAOs, like any other organization, are composed of more than just decision-making and treasury functions. They involve communication with these on-chain smart contracts, for example, reading proposals that are up for voting through a front end and also DAO community communication and collaboration. This is typically done "off-chain" (Fig. 3).

The front end often exists of a web page, where participants can view information regarding the DAO. Information can include elements like the goal of the DAO, their constitution (e.g., fundamental DAO rules of engagement), general information, and links to other important sites and tools of that specific DAO. Also, voting and treasury transactions can be traced and initiated in a user-friendly way through

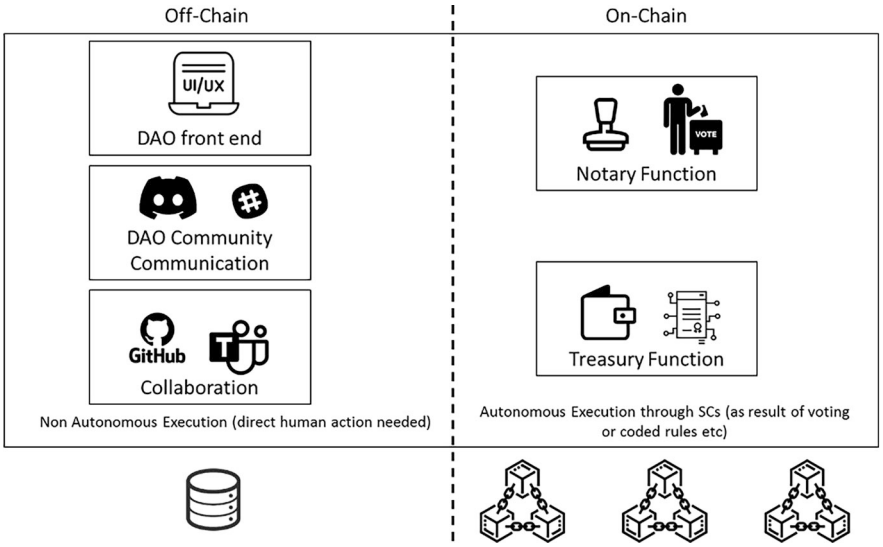

Fig. 3 Off-chain versus on-chain elements of DAOs

these web pages. These specific treasury and governance web pages are automatically created if one initiates their DAO through a DAO deployment platform, which will be elaborated on later in this section.

Another off-chain element of DAOs is related to community communication. Although there are some on-chain messenger possibilities, most DAO communities communicate through popular online communication tooling like Discord and Slack (Kaal, 2024; Quan et al., 2024). Collaboration can also take place using well-known online collaboration tooling like GitHub for code-sharing and software-building collaborative projects (Quan et al., 2024; van Vulpen et al. 2024b).

A DAO often consists of both an on-chain and an off-chain element, where the on-chain element (the smart contract facilitating the notary and treasury functions) truly makes these organizations decentralized and facilitates certain levels of autonomy. In theory, a DAO can exist without its off-chain part but not without its on-chain elements, although in practice joint operating environments are almost always a combination.

To initiate the on-chain part of a DAO, there are various ways to set this up as illustrated in Fig. 4. From a DAO deployment point of view, we can distinguish the following DAO archetypes.

In general, there are two main DAO deployment types. Either DAOs are deployed by means of the setup of completely dedicated blockchain infrastructure or on top of an existing blockchain infrastructure. It is argued that the Bitcoin network itself is a DAO (Hsieh et al., 2018). However, the vast majority of DAOs are smart contract-based DAOs, which are smart contracts that are being deployed on an existing (blockchain) infrastructure (Faqir-Rhazoui et al., 2021b; Rikken et al., 2023b).

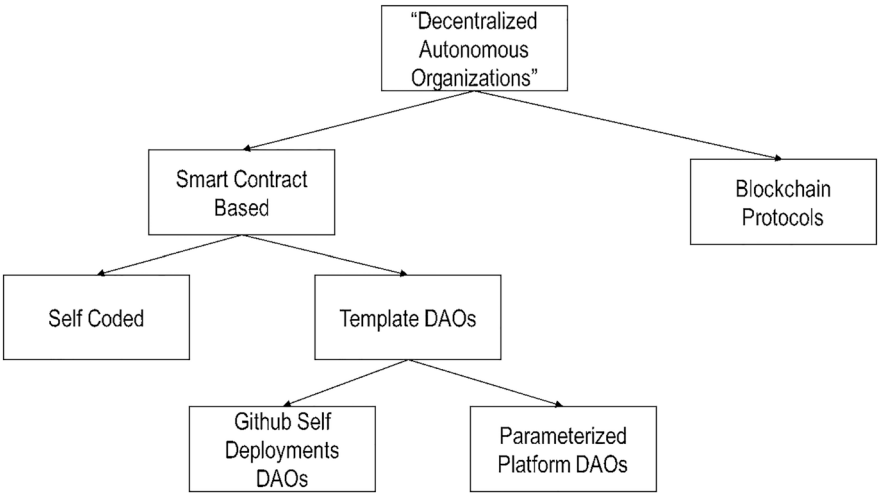

Fig. 4 DAO deployment archetypes. (Retrieved from Rikken et al. (2023b, p. 5))

In the beginning, most DAOs and their smart contracts were self-coded, meaning that the smart contracts were coded from scratch and deployed directly on the blockchain infrastructure. The end users can then, through their wallets, communicate (send in transactions) directly with the DAO smart contract accounts. Setting up DAOs in this way can be very labor-intensive and error-prone as all code has to be written by the engineers of the DAO themselves.

The other option is to use template DAOs. Template DAOs can be completed using on GitHub available online templates for self-deployment. In this approach, existing smart contract code for the DAO on-chain functionality is used, and developers can deploy it themselves of which eosDAC[2] was an example.

The easiest way to create a DAO is by using "no-code"-tools, by means of parameterized DAO deployment platforms. These latter arose around 2017–2018 through platforms like Aragon and DAOstack,[3] and later on, platforms like Colony and DAOHaus[4] caused a Cambrian explosion in the number of DAO projects (Rikken et al., 2023b).

These platforms enable nontechnical persons to create an on-chain DAO relatively easily. In addition to the creation of the on-chain part, the treasury, and notary functionality smart contracts, the user interfaces (UI/UX) are also automatically created. Using these user interfaces for interaction the on-chain DAO makes it possible to have a fully functional DAO, including a front-end, in a matter of minutes.

[2] https://github.com/eosdac

[3] https://aragon.org and https://www.alchemy.com/dapps/daostack

[4] https://colony.io/ and https://daohaus.club

Various information needs to be supplied from general information including a DAO description, links to external documents, discords, or websites. Furthermore, governance-related information like participants and decision models need to be supplied. Governance possibilities will be elaborated on in Sect. 7. After information is submitted, the DAO's smart contracts are automatically created, as well as a dedicated front end through which the participants of the DAO can interact with various organizational functions and externals can publicly view the DAOs information.

Although DAO deployment is made relatively easy for end users through these platforms, some prior knowledge and experience with web3 is required. Most importantly, there needs to be familiarity and possession of a web3 wallet and a blockchain-based account that contains a (small) amount of cryptocurrency to initiate the deployment transaction of the DAO. Given that a blockchain-based infrastructure require transaction fees in the form of cryptocurrencies, participating in the on-chain elements of DAOs (smart contract interactions) can require a certain (small) transaction fee. This financial requirement in itself, as well as the ratio of on-chain and off-chain action in DAOs, can pose certain governance, centralization, or de-autonomization risks, which will be discussed later in this chapter.

Setting up DAOs can be completed, as explained, relatively easily. DAOs can also support many business objectives, creating many opportunities for easy and collaborative governance in these organizations. There is no one form of DAO governance, which can be set up in many ways. We now shift the discussion to governance possibilities and issues.

6 What Is Meant by Governance?

Many definitions exist on governance, ranging from corporate governance (Baker & Anderson, 2010) and public governance (Fukuyama, 2013) to commons governance (Ostrom, 1990) and data governance (Janssen & Kuk, 2016). Building on earlier research by Rikken et al. (2024) on DAO governance, we adopt the definition of Weill and Ross (2005) and focus on three core elements essential for effective governance: accountability, decision-making, and incentives. These elements, in combination with the business objectives and underlying infrastructure, can have an influence on the long term viability of DAOs (Rikken et al., 2023a).

7 DAO Governance Mechanisms and Processes

As stated, there is no one type of DAO, they can differ based on business objectives, on deployment type, and from a governance perspective. Voting processes, decision models, accountability, and incentive forms can significantly differ across DAOs.

DAO governance can be based on functional decision and execution processes supporting the products and services the DAO is offering. DAO governance can also focus on processes supporting the update and evolution of the DAO. In practice,

from a process viewpoint, these are similar for the DAO participants but are resembled by different voting proposal types.

The governance process in DAOs can begin with a person creating a voting proposal. Then a decision is made following a given accountability and decision-making structure or policy. After decision-making, the action is executed according to the voting outcome. Incentives might be distributed if applicable.

Blockchain can be either permissionless versus permissioned. This means that there may be (or not) barriers to entry or exit in the governance of an infrastructure. Blockchains can also be public versus private, meaning there may be (or not) barriers to entry or exit in interaction with an infrastructure (Beck et al., 2018; Peters & Panayi, 2015; Rikken et al., 2019). We distinguish these two axes for DAOs as well, creating four main categories of DAOs as displayed in Fig. 5.

The public-private axis refers to the openness in initiation of proposals for decision-making. This environment is either open to anyone (public) or restricted to the participants of that DAO or even participants with a certain amount of voting power within that DAO (private). Permissionless refers to the fact that there is no barrier to entry into the governance of the DAO, meaning that anyone can obtain governance tokens, for example, by buying them without the prior permission of the sitting participants in that DAO. Permissioned DAOs restrict the acquisition of

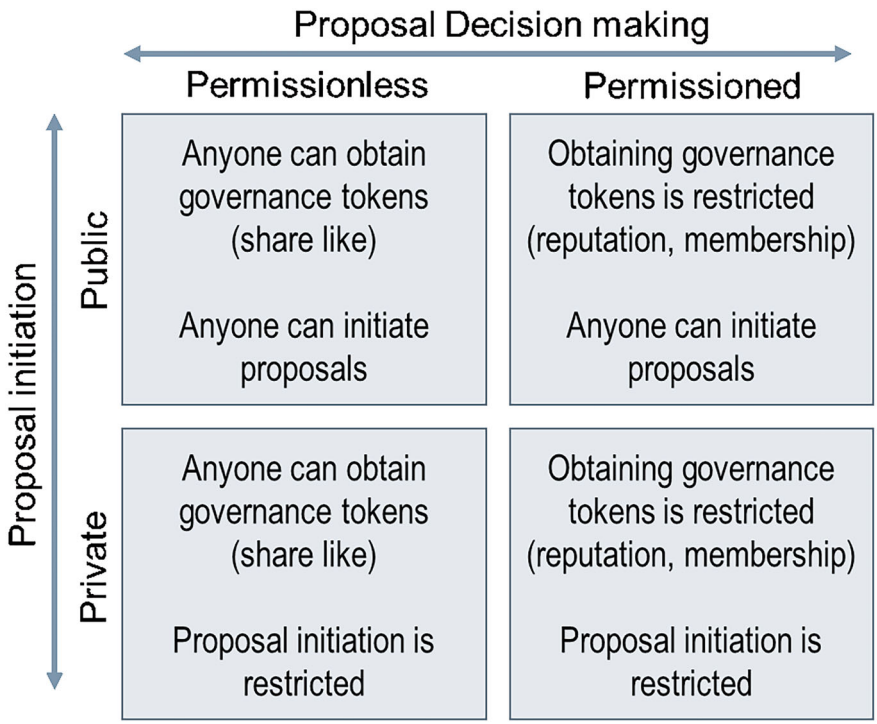

Fig. 5 DAO governance participation matrix

governance tokens by needing prior approval before a new participant can obtain governance rights and can actively participate in decision-making on voting proposals and, with that, could be eligible for certain incentives.

Voting and voting rights are, in general, measured and tracked using governance tokens. Based on the relative number of tokens to the total amount of governance tokens of that particular DAO, a certain account has more or less governance rights in a DAO.

Numerous sub-elements for accountability, decision models, and incentive structure governance elements exist. But on the highest level, within DAOs, according to Rikken et al. (2023a), per element, there are certain main sub-categorizations that can be distinguished within DAOs, as shown in Fig. 6.

Various court cases (Boniel et al., 2023; Kharif & Verspille, 2022) have specified that individual DAO tokenholders can be held accountable at some level for DAO operations and outcomes. Within DAOs, there may be **dictatorships**. In this situation, one token holder has all the practical voting power. Other token holders cannot pass a vote without that particular tokenholder's voting power. The other token holders will never be able to reach the voting quorum, which is the minimal percentage of the total amount of tokens that should have voted on a proposal.

Secondly, there are **semi-dictatorships**. In these DAOs, there is one majority tokenholder, but if this tokenholder does not participate in the voting, the other tokenholders can jointly reach the quorum and thus decide on a proposal. However, if the majority tokenholder votes, the outcome of the vote will always go in that direction.

Finally, there are **democracies**. In these DAOs, there is always a need for collaborative decision-making as no one tokenholder can single-handedly reach the quorum for decision-making. In this context, one token holder can always be overruled by a collaboration of other tokenholders in voting weight (Rikken et al. 2023a).

Recent research shows that DAOs have many tokenholders and are not dictatorships or semi-dictatorships and thus democracy. Yet, the Gini coefficient, displaying the relative voting power distribution, is high. This result means that a large part of the voting power is with a relative minority actual tokenholders (Peña-Calvin et al., 2024).

DAOs also have many different decision-making models. On the highest level, one can distinguish two main types of decision-making, either based on weighted voting power or on non-weighted voting power. There are many subtypes within these main types. The number of subtypes is especially extensive within the

Governance Elements Categories	Governance Element Classifications		
Accountability	*Dictatorship*	*Semi-Dictatorship*	*Democracy*
Decision Model	*Weighted*		*Non Weighted*
└> Detail Decision model	Share-like	Reputation	Membership
Incentives	*Direct*	*Indirect*	*Non*

Fig. 6 Governance elements categories and classifications based on Rikken et al. (2023a)

weighted model. For non-weighted models, all participants have equal voting weight. The governance tokens in these models are not tradeable—they can only be transferred back to the DAO if a participant no longer wishes to participate. In this situation, the total number of eligible voters will decline. The governance tokens cannot be traded with others. Within the weighted decision-making model, the individual voting power of the participants can differ. Therefore, not all participants necessarily have equal voting power.

Two main subtypes in weighted voting are either based on share-like models or on reputation-like models. In the share-like model, one can obtain additional governance tokens by trade. The governance tokens are thus transferable and tradeable, either via an exchange or peer-to-peer. One can buy and sell additional governance tokens and, with that, have more or less decision-making power within that DAO. These tokens generally have market-based prices (Appel & Grennan, 2023).

The reputation-based tokens are governance tokens that are earned by the tokenholders. The number can grow or decay based on the activity of that participant but is not transferable and thus not tradeable. Within these two subcategories, there are many other sub-sub forms of decision models. Some take time into account as a weight-enhancing mechanism called conviction voting, which states that if one signals for a longer time, the weight increases (Emmett, 2019). Others work with mechanisms like quadratic voting where one has to "pay" a certain amount of tokens in order to get a higher voting power. The more voting power one wants to use, the amount to "pay" growth quadratically (Lalley & Weyl, 2018).

Both within the weighted voting models as well as the non-weighted models, possibilities of delegation exist. Delegation means that an individual participant can delegate their voting weight to a delegate who can vote on their behalf (similar to a proxy). The delegator is also free to change this delegation to another delegate or decide to vote themselves if they did not delegate their vote to another.

While decisions within DAOs are continuously made by majority rules, there are also so-called *multisig constructions*. In these DAOs, there might not be a necessity of a majority to pass a vote. Instead, to pass a vote, a fixed number of participants have to sign off. Once that number is reached, regardless if it is a strict majority, the vote will be executed.

Three main subcategories of incentive typically exist: direct, indirect, and no incentive. **Direct** incentives are incentives that are rewarded to the governance token holder directly from a governance action. For example, a payment for performing a governance action or more reputation tokens if one actively participated in governance as seen in initiatives like Nexus Mutual or Decred. **Indirect** incentives are the result of an increase or decrease of the value of the governance tokens from good or bad DAO governance. In the case of share-like weighted decision models, tokens can be traded and thus made to value for the owner of the governance tokens. The DAO **no-incentive** category means there is no direct incentive mechanism nor an indirect mechanism due to token non-tradability.

Many DAO governance choices exist. There is no one size that fits all DAO governance models. Research shows the importance of the choice of infrastructure, governance elements of a DAO, and the business objectives of DAOs, as differences

in the configuration can have an influence on the long-term viability of the DAO (Rikken et al., 2024).

8 DAO (Governance) Challenges

As stated, DAOs create many opportunities for efficiency and increased democratization for participants in the organization. They are being used for many different business objectives, are relatively easy to set up, and have great flexibility for DAO governance setup.

Despite these opportunities and benefits, DAO usage comes with specific governance and functional challenges. We further explore these elements in this section.

The **promise of democratization** is seen as one of the main opportunities for the use of DAOs. But multiple challenges exist for this DAO promise. As stated in the previous section, **not all DAOs are, in fact, decentralized.** They can be dictatorships or semi-dictatorships. And even if they are democracies, many show high Gini coefficients for centralized control (Peña-Calvin et al., 2024). Although this latter observation has been used as an argument that DAOs often are not decentralized, this is not strictly the case. Within democracies, even with high DAO Gini coefficients, the DAO still requires decisions to be taken in consensus with others. Thus, no one participant can make one-sided decisions and will always need other participants for these decisions. Even these DAOs, although the division of voting power could be better, are arguably decentralized.

A risk that is related to the centralization of power is the *Sybil attack risk*. Participants identify themselves through an account number, but no proof of humanity is technically required. It is thus very well possible that a single person has multiple accounts (Fritsch et al., 2022; Rikken et al., 2023b). In this way, from the outside, it looks like a more even spread of governance tokens over multiple accounts, while in fact, there could be one person or instance behind it. Thus, ownership can become fuzzy (Rikken et al., 2019).

Another decentralization risk is the centralization of on-chain elements and off-chain elements control. The potential lack of autonomy is likely to exist in certain cases. Although the on-chain elements of DAOs are building in a decentralized infrastructure, the governance of these elements is not necessarily decentralized. The notary function and treasury functions, typically the on-chain elements, are run through smart contracts. It is possible to build in central control within smart contracts, even going so far that a single account is the only one eligible to perform actions, and thus highly centralizing them. This centralization algorithm is should be considered.

Off-chain elements can run on centralized controlled infrastructure, introducing a potential central control element. Recent high transaction fees result in that rise of solutions that even take the notary function off-chain through solutions like Snapshot. This shift leads to the fact that decisions are no longer autonomously executed and no longer are smart contracts and blockchain infrastructure involved. This situation creates the risk that although a decision is made, a person needs to execute

the decision, potentially not adhering to the decision. This risk has materialized in actual occurrences. These organizations thus lack autonomy and are therefore not DAOs.

The decision-making process through the notary function of DAOs is a crucial element. The setup of these processes and the behavior of the participants can pose a risk in itself. First, the speed of decision-making is often influenced by DAO parameter settings. Votes are open for a certain time period and only after the final count of votes is automatically done and executed accordingly. This situation means that votes are open for at least a certain time period. This opening could pose a risk if swift decision-making and action are required within a DAO (Rikken et al., 2019) and no separate process is defined.

Many DAOs see a decline in the activity of participants, so-called voter fatigue (Özdemir Sönmez et al., 2024). If DAOs are set up with a minimum quorum of voting participation, this fatigue could lead to limits in decision-making and, thus, a governance risk. This challenge can be solved by working with a relative majority in decision-making, so that there is no minimum quorum. But this situation runs the risk that only a small representation of the participants can make the decision. Another mitigation for voters fatigue could be via systems like lazy voting. Lazy voting means a proposal is autonomously executed unless a participant objects within a certain grace period. Only in that case the proposal is up to vote, limiting the number of votes for participants and with that the risk of voter fatigue.

A practical risk is the problem of interoperability for the transfer of value. At this point in time, the transfer of value through the DAO treasury function is only possible through crypto assets (cryptocurrencies, tokens, and stablecoins). Major advancements have been made on the legal and regulatory status of these crypto assets. For example, making these crypto assets (legally) usable through regulators like MiCAR within the EU. But, due to technical hurdles, it is not yet possible to send value from one blockchain infrastructure to another directly. This barrier means that a transfer of value needs to be done out of or into a DAO, and this needs to be done within the same infrastructure, for example, the Ethereum network.

Privacy is also an important factor to consider. All on-chain transactions on a blockchain infrastructure—similar to on-chain parts of DAOs—are publicly available. This transparency could pose a privacy risk. Although only account numbers and not names or other identifiable information can be seen, one can see the behavior of that account in votes. There are solutions being developed that can guard against this privacy concern, but they are not yet widely available (Arnaucube & Baig, 2022).

The use of blockchain as underlying infrastructure represents a very specific risk for DAOs. There is a situation where there is an entanglement in governance between the DAO application (the smart contracts and on-chain data of the DAO) and blockchain infrastructure (Rikken et al., 2019). There are blockchain infrastructure characteristics and elements outside of DAO control that can influence DAO governance. It is, therefore, important consider these issues in the DAO governance design.

This potential conflicting challenge is particularly evident in two ways: (1) the immutability of hard-coded rules and (2) the governance entanglement through transaction pricing. Data on blockchain infrastructures, including stored code through the use of smart contracts, are practically immutable. This characteristic means that once the smart contract code, reflecting the on-chain capabilities of DAOs, is deployed, it cannot be altered anymore. Thus, the design and setup of smart contracts need to be very carefully developed and implemented. Although the initial code itself cannot be altered, variables in the code can be updated. Also smart contract functions can be made upgradeable but for both only if they are prepared for that in the initial deployment. In this way, alteration is possible. Otherwise, coded rules are truly hard-coded indefinitely (van Vulpen et al., 2024a).

The price of transactions needed to perform on-chain actions within DAOs are under the control of the governance of the blockchain infrastructure, not the DAO themselves. The transaction price influences DAO governance. A higher transaction price can lead to lessened participant DAO governance activity. This lack of participation poses a risk to the governance of the DAO itself as one runs the risk of inactivity around decision-making as voting requires a transaction (Faqir-Rhazoui et al., 2021a; Rikken et al., 2024).

Business objectives and governance elements, including the entanglement with the governance of the infrastructure need to be considered in DAO designs. Certain combinations can positively or negatively influence the long-term viability of DAOs (Rikken et al., 2024).

9 The Road Ahead: Emerging Opportunities and Challenges

DAOs have shown remarkable growth over the past few years, both in numbers and in size. They bring various opportunities for organizations and entrepreneurs. DAOs and their landscape are continuously and rapidly evolving, from new technical to new legal developments. This evolving environment is creating more clarity and more opportunities for using DAOs. Rikken et al. (2024) identify three critical axes that might influence the future of DAOs and their usage and acceptance. One is technical-related, one is regulatory, and one is related to user acceptance.

From a technical perspective, there are multiple relevant developments. First, new decision models and smart contracts are supported, with privacy further guaranteed. This development can be achieved by the integration of solutions like blind OVOTE guaranteeing privacy in voting (Arnaucube & Baig, 2022) and *zero-knowledge proofs,* which are cryptographic techniques that allow data minimalization when a prover needs to prove a state or statement to a verifier (Fiege et al., 1987). Additional smart contract functionality can be integrated. Early DAOs predominately supported the autonomous notary and treasury functions within DAO smart contracts; now more DAO API constructions are being implemented, making integration of other external smart contract functionality in the DAO possible. This further integration increases the amount of on-chain DAO functionality.

Secondly, in various initiatives, there is a clear movement to integrate other technologies, especially AI. This leads to increased possibilities for autonomous decision-making and execution by a DAO, leading to ever-increasing autonomy levels in AI-enhanced DAOs.

Another important development is on the legal and regulatory side. Where prior, there was ambiguity on DAO legal status and crypto assets that are crucial for the transfer of value of DAOs, and many recent legal and regulatory developments are being set in motion to address this ambiguity. For example, special legal wrappers for DAOs are being developed in the United States (e.g., Vermont) and various Caribbean jurisdictions (e.g., Bermuda or British Virgin Islands), creating legal clarity. Legal clarity makes DAO business interactions easier.

Major developments are on the rise for crypto assets. In Europe in 2024, EU-wide regulation on crypto assets, the Markets in Crypto Asset Regulation (MiCAR), was introduced, making crypto asset and service providers around crypto assets regulated. This regulation creates more trust and thus more business possibilities in the usage of crypto assets for transfer of value, including payments through US Dollars or Euros variances of crypto assets, so-called stablecoins.

Another future issue is user-friendliness. This user friendliness is important for DAOs and wider web3 applications. The need for wallets and cryptocurrencies to interact with DAOs can still be a challenge. There are developments to lessen this barrier, but this is still in the early stages. Through the standard UI/UX presented through the DAO deployment platforms, the interaction is also becoming more user-friendly. A further increase could potentially benefit the adoption of DAOs.

Finally, the acceptance by the end users themselves will play a crucial role in the acceptance of DAOs. One of the main promises of DAOs is democratization and more participatory opportunities not only in businesses but also in public private cooperation and citizen participation (Rikken et al., 2022). What remains to be seen is the willingness to participate in the governance of DAOs, as the trade-off of decentralization and democratization in DAOs entails responsibility and accountability in decision-making.

10 Conclusions

DAOs present many opportunities for businesses as they create the possibility of more democratic and (community) co-owned organizations and participative opportunities for end users in organizations, including economic opportunities that were previously less accessible to the average person. Currently, DAOs are used for a wide range of business objectives and are growing fast in numbers and size. Given the right circumstances, they have the potential to further grow and integrate into daily business.

DAOs offer many (business) advantages, including internal organizational democratization, external actor participation, transparency, accountability, advanced auditability, autonomy and automation, higher efficiency, lower cost, increased trust, and new organizational and governance forms.

It is important to note that there is no such a thing as a "SINGLE DAO." Different configurations yield different benefits and might serve different business objectives. Given the broad range of choices in technology, deployments, and governance setup, DAOs, although they all chase a democratic participative setup with autonomous execution of notary and transfer of value functionality, are very flexible and can be tailored to the unique needs of the community behind the DAO. As such, DAOs are likely to be adopted in an increasing number of settings in the future.

When establishing a DAO, careful consideration must be given to the governance setup, business objectives, and the underlying blockchain infrastructure, as these factors can significantly influence the long-term viability of DAOs. Certain business objectives are more suitable for a DAO setup than certain governance setups. Knowledge about both the technology and organization are needed to develop viable DAOs.

Looking at future development, the level of autonomy in DAOs is currently limited to the autonomous execution of the coded rules in the smart contracts that support notary and transfer of value functions. However, there is a clear extension of autonomous functional possibilities through interfacing with other smart contract functionality and first explorations in integrating AI into DAO decision-making processes.

In conclusion, DAOs hold immense potential for new forms of organizational and online governance. However, they still have their own risks and limitations. Given the flexibility in their setup, the potential consequences of these choices should be properly addressed in setting up a DAO.

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