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A comparative analysis of the platforms for decentralized autonomous organizations in the Ethereum blockchain

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Abstract

Blockchain technology has enabled a new kind of distributed systems. Beyond its early applications in Finance, it has also allowed the emergence of novel new ways of governance and coordination. The most relevant of these are the so-called Decentralized Autonomous Organizations (DAOs). DAOs typically implement decision-making systems to make it possible for their online community to reach agreements. As a result of these agreements, the DAO operates automatically by executing the appropriate portion of code on the blockchain network (e.g., hire people, delivers payments, invests in financial products, etc). In the last few years, several platforms such as Aragon, DAOstack and DAOhaus, have emerged to facilitate the creation of DAOs. As a result, hundreds of these new organizations have appeared, with their communities interacting mediated by blockchain. However, the literature has yet to appropriately explore empirically this phenomena. In this paper, we aim to shed light on the current state of the DAO ecosystem. We review the three main platforms nowadays (Aragon, DAOstack, DAOhaus) which facilitate the creation and management of DAOs. Thus, we introduce their main differences, and compare them using quantitative metrics. For such comparison, we retrieve data from both the main Ethereum network (*mainnet*) and a parallel Ethereum network (*xDai*). We analyze data from 72,320 users and 2,353 DAO communities in order to study the three ecosystems across four dimensions: growth, activity, voting system and funds. Our results show that there are notable differences among the DAO platforms in terms of growth and activity, and also in terms of voting results. Still, we consider that our work is only a first step and that further research is needed to better understand these communities, and evaluate their level of accomplishment in reaching decentralized governance.

Keywords: Blockchain, DAO, Decentralized autonomous organization, Distributed systems, Ethereum, xDai, Governance, Online community, Quantitative research, Voting

1 Introduction

Blockchain technology has enabled the emergence of a new kind of distributed system. It provides mechanisms in which decentralized transactions and operations are secure, without the need to trust a mediating third-party as it is common in server-centric centralized systems[1] [1, 2]. Due to its origins linked to cryptocurrencies, blockchain has been mostly applied to financial applications. However, in recent years it is increasingly applied to other fields [3]. A specially interesting application is the emergence of new forms of decentralized governance which are mediated by a blockchain. These blockchain-enabled organizations are known as Decentralized Autonomous Organizations (DAOs), and take benefit of the affordances of blockchain infrastructure to enable e.g. transparent decision processes, formalized rules, automation of certain operations, or alleged decentralization of power [4].

The blockchain field has attracted a broad range of experts and enthusiasts [5], currently with a majority belonging to the fields of Computing and Finance, and focused on new financial applications, e.g. the booming *DeFi* field[2]. Some of these projects chose to rely on DAOs for their governance. Thus, the project's online community may use the DAO embedded decision-making mechanisms to vote proposals and organize their tasks. In order to meet this demand, several platforms have recently appeared to provide DAOs as-a-service, that is, deploying DAOs in a public blockchain and facilitating community interactions through them. These platforms have reduced the technical knowledge required to operate through a DAO, and thus thousands of people are now interacting within hundreds of DAO communities.

This new phenomenon can be followed on the Internet, particularly, through 'grey literature' including technical reports, blogs, social media posts, etc. Research literature has covered it mostly with theoretical works [4, 6, 7], although some empirical works have been slowly emerging. We can highlight qualitative research such as an ethnographic account of the first popular DAO [8], a comprehensive study understanding the imaginaries behind DAOs [9], or a content analysis of grey literature on three popular DAOs to understand how are they governed [10]. In [11] we can find an overview of DAOs, DAO platforms and DAO visualization tools, and a analysis of the evolution of one popular DAO looking at the time series of metrics such as the number of users and actions performed in the DAO. Recently, a study analyzed how affected on DAO activities the increases in the costs of using the Ethereum blockhain that took place in the second half of 2020 [12].

In this paper, we will contribute to the growing stream on literature on the topic by providing a statistical analysis of three of the main DAO platforms (Aragon, DAOstack and DAOhaus) in terms of growth, activity, voting system and funds.

The article proceeds as follows: Section 2 introduces the main concepts related to blockchain, Ethereum and DAOs. In Section 3, we review the three DAO platforms that we are going to analyze in this work. Section 4 compares the three main DAO platforms in terms of growth, activity, voting system and funds. Section 5 proceeds to discuss the main findings, while Section 6 finishes with some concluding remarks, including the limitations of our work.

[1] Note that trust is displaced to other components, like the need to trust the algorithms and cryptography used, or the developers creating such algorithms.
[2] DeFi means Decentralized Finance, typically blockchain-enabled

2 Blockchain and DAOs: the field in a nutshell

2.1 Blockchain

Blockchain is a distributed ledger, which can be understood as a distributed append-only database with a synchronization mechanism. Like the Internet, a public blockchain is an open infrastructure, not owned or controlled by one central authority. Generally, the ledger database is replicated in each of the network nodes, and thus can be viewed by all its users [2, 13]. Thus, we consider transactions and operations in public blockchains to be transparent, since they can be tracked and seen by any participant in the network.

The ledger is a sequence of blocks (hence block-chain) that contains a set of transactions already performed[3]. Each block points to the previous block in the ledger, forming a chain. When a user wants to add a new transaction to the ledger, the transaction data is verified by the so-called miners. If there is consensus on the new block validity, it is added to the chain in a decentralized process [1, 2]. Furthermore, the blockchain grants immutability of its past records: nobody can delete and alter the data of the block placed within the validated chain [14].

The first implementation of the blockchain technology was *Bitcoin*, which is a "cryptocurrency", i.e. decentralized digital currency validated through cryptography [15]. After that, thousands of new cryptocurrencies have emerged with their own features [16].

The second wave of blockchain was prompted by the advent of *Ethereum* in 2013 [17]. Ethereum provides a distributed computing platform and a programming language, *Solidity* [18]. *Solidity* addressed several limitations of the *Bitcoin*'s scripting language, like the lack of Turing-completeness [19]. This has enabled multiple types of decentralized applications (Dapps) and the so called "smart contracts", computational agreements between parties which may be self-executed and self-enforced.

Dapps have been applied in many fields [20, 21], specially on Finance. Thus, we may highlight examples such as banking services [22] or cryptocurrency payments [23], leading to the surge of Decentralized Finance (DeFi), a form of finance that does not rely on central financial intermediaries used to get crypto-savings, crypto-loans, or trade with them [24]. Beyond Finance, we may mention IoT, using blockchain as a common communication layer [25], or supply chains, facilitating traceability and desintermediation [26].

In the context of this article, the most relevant field where blockchain and smart contracts have had an impact is in enabling new forms of decentralized governance, such as Decentralized Autonomous Organizations (DAOs), where decision-making is distributed or delegated away from a central authority.

2.2 Decentralized autonomous organizations

A DAO is a blockchain-based system that enables people to coordinate and self-govern themselves mediated by a set of self-executing rules deployed on a public blockchain, and whose governance is decentralized, that is, independent from central control [27].

DAOs are organizations in the sense that they mediate the interactions of a group of people, typically an open community that joins as members. In some DAOs, members are

[3] In cryptocurrencies, each block holds transactions, i.e. movements of cryptocurrency between accounts. In other more general applications such as Ethereum-based apps (and DAOs), blocks contain operations, akin to typical instructions in a computer program, that need to be executed.

token holders of a certain token that enables DAO participation, similar to corporation shares.

DAOs are considered autonomous because, unless its code explicitly says so, they are independent from their creators. Their operations follow the rules embedded in its code, together with the (human) governance of its members. Moreover, being deployed on a public blockchain, they are censorship-resistant, since there is no central controller that may turn off the DAO and its provided service. Thus, as long as there are members willing to execute their code, DAOs will continue operating, e.g. providing services, purchasing/selling resources or hiring people.

DAOs are considered decentralized first because of relying on a server-less decentralized infrastructure (a public blockchain). Second, because they rely on certain decentralized governance mechanisms, so the decision-making process relies on the collective agreement of its members. This process typically relies on some form of voting, in which the DAO members can participate. Note that such decisions may refer to e.g. the allocation of the DAO resources (e.g. funding projects or payments to members), but also may refer to changes in the DAO code. That is, upon the agreement of its members, a DAO may be updated to operate differently, with a new set of encoded rules. This may be critical to fix a bug in the code, but also enables it to adapt to community needs and demands [28].

DAOs are deeply related with Ethereum, the most important general-purpose public blockchain [29, 30]. In Ethereum, every operation performed implies a cost, i.e. a commission to be paid by the user, for the miners to perform the requested operation. In practice, validating and performing those operations require a certain amount of computational work performed by miners. The amount of computation required by an operation is named *gas*, and it is paid in cryptocurrency; in Ethereum, with its token Ether. For the user approach, gas ultimately translates into money and the amount of gas depends on the size and type of each operation. Hence, the Ethereum blockchain can be seen as a costly and secure distributed database system.

DAO activity is typically recorded into the blockchain[4]. This fact conditions the type of data that a DAO stores in the blockchain, since blockchains are not designed for massive storage. For example, DAO members typically use other complementary off-chain tools for their communication, such as forums like DAOtalk[5], since DAO software does not usually offers interactive communication tools. Consequently, this technological aspect surely affects the behavior of DAO communities and could make it substantially different from other online communities. See for example how the increases in the Ethereum cost affected the DAO activity in 2020 [12].

The first popular DAO implementation received the (confusing) name of *TheDAO*, launching in April 2016 within the Ethereum blockchain. *TheDAO* was a sort of hedge fund, in which contributors could directly vote proposed projects. It became the most successful investment crowdfunding in history at that time, raising $150M, and concentrating the 14% of all ether tokens issued at the time. In June 2016, due to an error in *TheDAO* code, an attacker stole $50M [31]. The impact of the event stirred debate,

[4]User actions are recorded as specific software operations into the blockchain. Operations are named "transactions", given the origin of the blockchain as a ledger for a cryptocurrency.
[5]https://daotalk.org/

resulting in the Ethereum community deciding to "hard fork" the Ethereum blockchain[6] and return the stolen funds to the original *TheDAO* investors. However, the concept of immutability of the ledger past records was damaged due to this event, and part of the community continued operating under the old rules, in a blockchain named Ethereum Classic (in which the funds were stolen and not reverted) [32].

This event was somehow traumatic for the blockchain community, and had multiple implications. Still, the endeavor of creating decentralized organizations to operate in the blockchain persisted. However, it was widely recognized that the complexities of blockchain programming make the task of creating a DAO from scratch a highly risky project, even for specialists [8]. As a result, new solutions emerged to facilitate templates and tools to dramatically reduce both the risks and the technical knowledge required to deploy DAOs.

3 DAOs enabled by a platform

The platforms that provide DAO deployment as-a-service enable users to create their own DAO using a template that typically can be customized. The main platforms are *Aragon*, *DAOstack*, *DAOhaus* and *Colony* [11]. All are free/open-source projects in development, in different maturity stages.

Colony will not be covered in this article due to its early development stage, with, to the best of our knowledge, just two DAOs deployed in the platform so far, and no APIs to retrieve the data. It is worth mentioning that Colony DAOs break with the typical proposal-driven schema of functioning, where each action of the DAO must be voted. In Colony, DAOs are task-driven, which means tasks are published, and members accept them for a payout [33]. Thus, the mechanics of task-driven vs proposal-driven DAOs may add complexities when pursuing comparisons in the future.

3.1 Aragon

Aragon[7] is by far the largest DAO platform, with currently 1700 DAOs collectively managing $900M. Aragon aims to extend the use of DAOs as a free and open-source technology to allow the creation and management of decentralized organizations [34] under different forms including companies, cooperatives, nonprofits, or open-source projects.[8]

Aragon provides a static template to make your own DAO, but it also allows you to create a customized one. Customization is enabled through "apps" (sets of smart contracts), which can be installed or removed from DAOs via voting. The purpose of apps varies widely, including: a *Finance* app to allocate the DAO's funds, an *Agent* app to interact with other Ethereum smart contracts, a *Token* app to manage the membership, or a *Vote* app used as a decision-making system [35, 36]. In addition, Aragon provides a *SDK*[9] to create and deploy smart contracts, apps, and organization templates (i.e. a set of predefined apps and a customized configuration for the template purpose).

[6] A fork occurs when a blockchain diverges into two paths forward, due to a change of the encoded rules: a blockchain path follows the old rules while the new path follows the new rules. Typically, only one path is considered the "valid" path; however, both can still be used. A "soft fork" maintains some sort of compatibility (backwards-compatible) and thus just requires a majority of the network to agree on it. A "hard fork" is a more radical change, which requires all the network to follow the new rules, making the blocks following the old rules invalid.
[7] https://aragon.org/
[8] https://help.aragon.org/article/4-about-aragon
[9] https://hack.aragon.org/

In this article, we will focus on the *Vote* app, since voting is the main action in most DAOs. Furthermore, the default Aragon voting app is one of the most used apps in Aragon DAOs[10]. Its decision-making system works as follows. The app defines two conditions that any voting must fulfill to be approved:

1 The majority required: From all cast votes, the percentage of positive cast votes must be greater than or equals to the *required percentage of support*.
2 The minimum participation required: The *minimum acceptance quorum* parameter states the minimum percentage of votes cast from all possible votes in the DAO.

Note both parameters may be changed via voting.

However, voting in Aragon goes beyond the Voting app, since there are other apps for voting and decision-making. For instance, there is an app, currently in development, which implements the decision-making system of the DAOstack platform, Holographic Consensus [37] (explained below). Another notable example is the *Dandelion voting* app which implements the decision-making system of *Moloch* implemented in the DAOhaus platform (explained below). Furthermore, the *Dot-Voting* app adds the possibility to vote with more than two answers instead of the typical binary answer (yes/no).

Another ambitious decision-making system implemented as an Aragon app is *Conviction Voting* (CV) [38], which derives from the work on *Social Sensor Fusion* [39]. CV aims to represent the aggregated preference of individuals on proposals, expressed continuously, and not just in a punctual "voting" window. Thus, individuals express their preference (vote) on certain proposals, and the longer they keep the preference on a certain proposal, the longer their "conviction" on such proposal will grow. Individuals may change their preference (vote) at any given time. In DAOs, members represent their preference allocating their limited tokens to one or more proposals. The longer they keep them there, the more conviction the proposal will accumulate and the higher the chances it will reach the threshold to pass. Note such threshold is dynamic, and dependent on the DAO treasury funds [38, 40]. CV was tested through simulations[11], and Aragon makes it possible to deploy it in a real environment [41].

There are other ways to change the decision-making processes in Aragon, changing not just the voting app, but how the organization works. For instance, the *Committee* template [42, 43], which facilitates creating different committees (sub-groups) within a DAO. The DAO community may delegate certain decisions or tasks to those sub-groups, which may operate autonomously. The idea is to facilitate scalability in decision-making processes[12], reducing the number of people involved.

3.2 DAOstack

DAOstack[13] is a platform that aims to tackle the governance scalability problem. Matan Field, co-founder of DAOstack, states that the bigger a DAO is, the harder it is to manage it [44], which mimics the classical issues of governance in groups. In principle, we can specify DAOs where all decisions are taken by voting and a 51% majority is expected for a proposal to pass. Such model is feasible for small DAO communities, where the number

[10] See "Installed apps" chart in: http://dao-analyzer.science/aragon
[11] https://github.com/1Hive/conviction-voting-cadcad
[12] Scalability in terms of growing a DAO membership and its operations (i.e., votes, tasks, etc.)
[13] https://alchemy.daostack.io/

of proposals does not escalate further than what the number of members can study and decide on. However, the higher the number of members, and thus the number of proposals, the more proposals need to be reviewed by each member in order to participate. A naive solution to this matter could be to reduce the required quorum (i.e., pass proposals with a relative majority), but this introduces new flaws. For example, an attacker could spam requesting the DAO funds, i.e. send plenty of proposals in a small time frame. Thus, it may overwhelm the community, making it easier to get the funds using a lower quorum. Thus, increasing the number of DAO members may reduce the DAO resilience.

To face this problem, DAOstack proposes the *Holographic Consensus* (HC) decision-making system [45, 46]. In HC, DAO members send and vote for proposals, which pass by absolute majority (51%). However, there is an alternative method for passing proposals. The idea is to create a prediction market as a middle layer: community members[14] may "bet" if a certain proposal will pass or not pass, staking a certain amount of their tokens (cryptocurrencies). If a proposal receives enough stakes, reaching a threshold, it may skip the requirement of absolute majority voting and be passed with a relative majority. Afterwards, stakers may resolve their bets, depending if they guessed correctly (earning tokens) or not (losing tokens). If HC works correctly, it will act as a filter for the community, which may focus on the proposals that attract attention from stakers. Stakers thus filter out bad proposals, enabling a better scalability for large DAO communities. And the DAO may rely on stakers since they are incentivized to be aligned with the DAO overall opinions, since they need to guess if the voted proposals will eventually pass or be rejected. Preliminary research shows that HC works as intended [47].

3.3 DAOhaus

DAOhaus[15] is a platform which enables the creation of DAOs mimicking the behavior of the *Moloch* DAO. Moloch DAO was a grassroots response to coordination problems in funding Ethereum 2 and other community grants.

DAOhaus DAOs implement a straightforward voting system, which is basically a non-quorum system, where always a relative majority is enough to approve a proposal. This way to proceed simplifies development and testing processes [48] of their voting system. A key aspect from these DAOs is the "rage quit" mechanism that makes it possible to exit a DAO with your portion of the DAO resources if you do not agree with the result of a voting. After the voting outcome is achieved, there is a 'grace' period, when DAO members can quit if they do not agree with the outcome. Additionally, if there are more than ≈30% of rage quits, then the vote will be automatically rejected [49]. The idea is similar to the right to fork in free/open source communities: just the fear of fork makes communities more prone to consensus, promoting sustainability and facilitating governance [50].

This voting system has two main attributes to consider: shares and tributes. Shares refer to an amount of resources that each DAO member has, independently of the cryptocurrencies the DAO has. And tributes refer to an amount of shares the proposal applicant pays to the DAO. Thus, in a proposal, the applicant can request shares and/or pay a tribute, which helps define the kind of proposal. For instance, if a proposal has just a request of shares, it typically belongs to a project proposal (performing a certain task for the com-

[14] Although other people, external to the DAO, may be allowed to stake as well, depending on the implementation.
[15] https://daohaus.club/

munity in exchange of the shares). If a proposal has just tributes, it represents a donation to the DAO [51].

Nowadays, DAOhaus DAOs split into two groups. Those created in the early stage of DAOhaus (Moloch v1 DAOs), and those created with new features of *Moloch v2*. Some changes introduced in Moloch v2, include the ability to expel a DAO member from the community. It also includes some changes like the ability to send proposals by non-DAO members, or some changes related to its voting system, described below [49].

Moloch v2 introduces the sponsorship, which slightly changes the voting system. Now, when a proposal is sent, it requires the sponsorship of a DAO member. Such sponsorship is performed when any DAO member makes a deposit confirming that it is trustful. All the proposals need to be sponsored before moving on to the regular queue, where the voting starts [49]. When the voting ends, independently of the outcome, the sponsor will get a portion of her deposit back. In this way they intend to avoid attackers to spam plenty of proposals to exploit the non-quorum characteristic of the *Moloch* voting system.

4 Quantitative comparison of the three main DAO platforms

We will compare the three main DAO platforms introduced in the previous section, i.e., Aragon, DAOstack, and DAOhaus, using two DAO visualization tools: *DAO-Analyzer*[16] [11] for the adoption and activity metrics, and *DeepDAO*[17] for the fund statistics. The data used in this comparison covers, from the start of activity of each platform[18] to November 30, 2020. The data collection process is described in the Appendix.

The comparison will tackle four dimensions that will help us to better understand the DAO phenomenon: growth, activity, use of the voting system, and the funds owned by DAOs. Growth statistics will help us to analyze the adoption of DAOs: how many of them are and, how many people is involved. Activity metrics will help us to determine how many DAOs are operative and how many users are involved, because it may happen that DAOs are abandoned, as happens in other online projects, such as wikis [52], or that some members may abandon the project or barely participate. Since one of the most prominent features of DAOs are their voting systems, we will also analyze them to see how they are used by means of participation statistics, and percentages of proposals approved and positives votes. Finally, we will have a look at the cryptotokens used by DAOs, particularly, we will analyze their adoption and the funds managed for the richest DAOs.

It is important to remark that in our analysis, we will include both the DAOs deployed in the *Ethereum mainnet* and the DAOs deployed in the *xDai* network. The use of the Ethereum mainnet implies the payment of a fee (the gas cost of the computation), and this fee is tied to the network's use. In mid-2020, the use of the Ethereum mainnet spiked, increasing dramatically the fees to process any transaction (e.g. voting, DAO creation). As a result, DAO platforms searched for alternatives to avoid such expensive prices. One of the most successful solutions was the case of the xDai network. xDai is a blockchain designed for fast and inexpensive transactions. It has a bridge with Ethereum mainnet (it is a *sidechain*) facilitating the move of tokens from each other. Table 1,[19] shows the cost

[16] https://dao-analyzer.science/
[17] http://deepdao.world
[18] The Aragon platform started in October 2018, DAOhaus in February 2019, and the DAOstack platform in April 2019.
[19] Source: https://web.archive.org/web/20210303025348/https://daohaus.club/help

Table 1 Comparison of the prices of two DAOhaus operations and the average speed, in both the Ethereum mainnet and xDAI networks in October 2020

	Summon	Vote	Speed
mainnet	$80	$5	5 tps
xDai	$0.01	$0.001	70 tps

to create a DAO (*summon*) and to vote in the DAOhaus ecosystem, both in the Ethereum mainnet and xDai. As the table shows, the mainnet is orders of magnitude more expensive (and slow) than xDai. Note xDai, in turn, is less decentralized than Ethereum and it is dependant on it.

Before analyzing the four aforementioned dimensions, we will examine the use of xDai and mainnet. Table 2 shows the number of DAOs, users, and proposals per platform and by network (mainnet and xDai). Aragon is by far the most important platform in terms of DAOs, users and proposals. Regarding the number of DAOs , DAOhaus comes second with more than 200 DAOs in mainnet and xDai, while DAOstack has 59 (considering mainnet and xDAI). However, in terms of users DAOstack is more populated than DAOhaus.

Regarding xDai adoption, in Aragon xDai DAOs represent 15.71% of the total number of DAOs, while xDai users are 30.1% of the total. Aragon started using xDai from July 2020. Note there is no available data about the proposals in xDai in Aragon.

In the case of DAOhaus, xDai DAOs are 24.89% from its total, while xDai users are 18.34%, and the xDai proposals represent 24.93% of all proposals. Similar to Aragon, DAOhaus uses xDai since July 2020.

Finally, in DAOstack the DAOs in xDai are 62.71% from its total, xDai users are 45.51%, and the number of xDai proposals are 19.16% from the total. The adoption of xDai in terms of users and DAOs is significantly higher than in the other two platforms. This may be explained by the fact that DAOstack started using xDai earlier, since February 2020.

These figures illustrate the importance of the xDai network in the DAO platforms. Hence, we will include xDAI in the comparisons in the following sections.

4.1 Growth over time

Given DAOs are an early field relying on a novel technology, growth by early adopters is critical for the future mainstream adoption. In fact, observing the growth over time of an online community, we may observe e.g. if the growth of the platform is healthy, or if it has stalled.

For the comparison of the platforms concerning growth over time, we will use two metrics: the number of DAOs and the number of users. However, the timestamp of the DAO creation currently is not available for DAOstack DAOs, while the timestamp of the user registration is not available for Aragon DAOs.

Table 2 Comparison of the three DAO ecosystems in terms of their number of DAOs, users and proposals

	Aragon		DAOhaus		DAOstack	
	mainnet	xDai	mainnet	xDai	mainnet	xDai
Number of DAOs	1,744	325	169	56	22	37
Number of Users	41,021	17,660	1,180	265	6,645	5,549
Number of Proposals	10,246	-	1,668	554	1,954	463

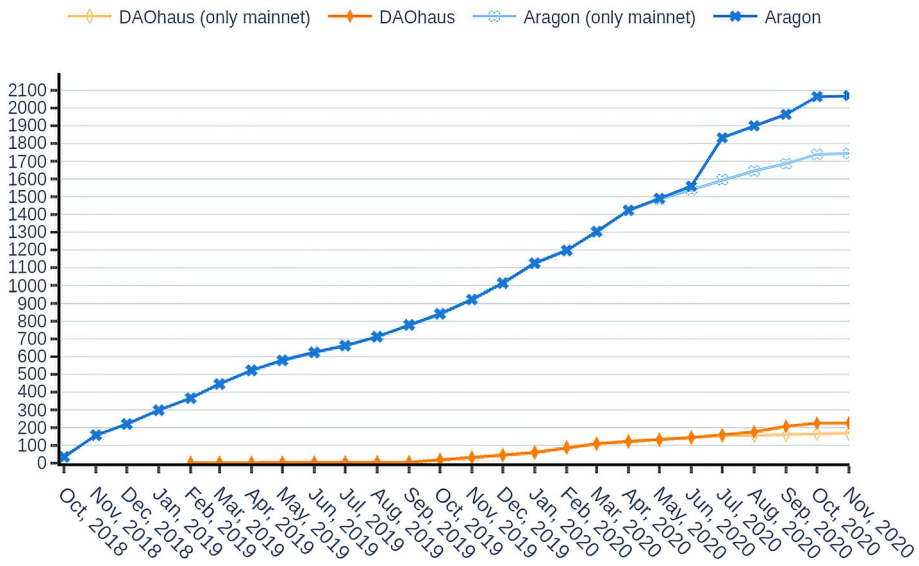

Fig. 1 Total number of DAOs of Aragon and DAOhaus, differentiating DAOs just in mainnet, and in both mainnet and xDai networks

Figure 1 shows the evolution in the number of DAOs in Aragon and DAOhaus.[20] It shows that the growth of Aragon in the Ethereum mainnet was constant and it even seems boosted by the xDai DAOs. On the other hand, the growth exhibited by DAOhaus was more modest. The new DAOs created in xDai can be brand new DAOs or DAOs that 'migrated' from mainnet DAOs; however, the DAO migration implies the creation of a new DAO with a different id and account. Thus, our data does not reflect when a xDai DAO is new or the result of a migration process.

Figure 2 shows the evolution of the number of users in the DAOs of DAOstack and DAOhaus.[21] It shows the number of users of DAOhaus and DAOstack. We can see two steps in the DAOstack series. The first step took place in June 2019 when 5,397 new users joined the project and almost 5,000 joined to the same DAO [47]. In February 2020, the second step (2,822 new users) was due to the launch of the xDai network. That is clear in the figure, since the gap between the dark and light green lines corresponds to the new xDai DAOs. Besides these two remarkable increases, the user growth was steadier and much more modest.

By contrast, the user growth in DAOhaus had no significant increases. Still, the growth is more pronounced since April 2020, even if the scale of the plot makes difficult to appreciate it. In addition, as we previously explained in Section 3.3, DAOhaus users can easily quit from a DAO (rage-quitting). Thus, the number of users could be higher, because 311 people used the 'rage quit' option during the period analyzed and such option is not available in other platforms, where users just abandon their accounts.

4.2 Activity over time

Growth is highly relevant, and yet it typically does not provide the full picture. Similarly to other online communities or online platforms, it is different to mention the number

[20] Due to the lack of a DAO creation timestamp in the API, DAOstack is omitted in this figure.
[21] Due to the lack of a user creation timestamp in the Aragon API, that DAO platform is omitted in this figure.

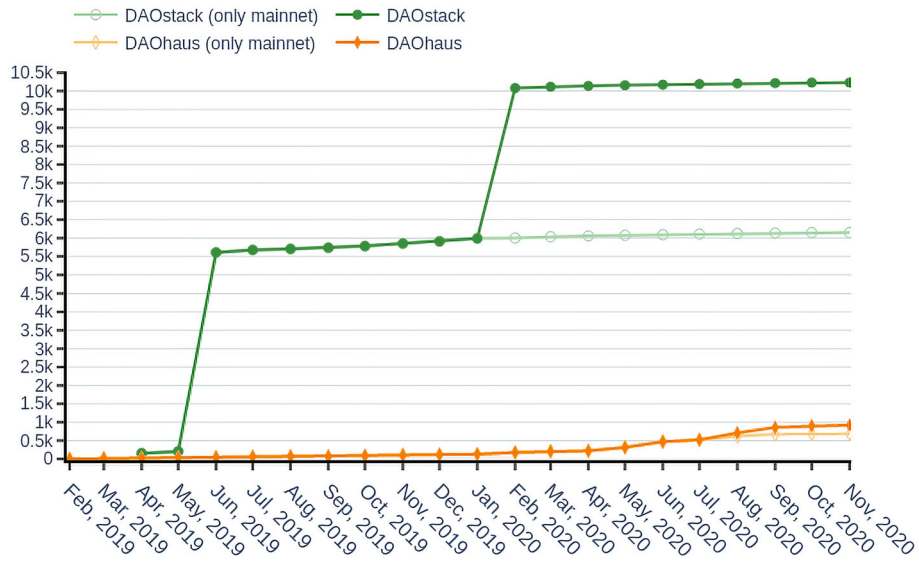

Fig. 2 Total number of users in DAOstack and DAOhaus, differentiating users just in mainnet, and in both mainnet and xDai networks

of users vs the number of active users. Thus, in this context it is highly relevant to also differentiate between DAOs and active DAOs, or users and active users. This will allow us to better compare the platforms use, focusing on the users and DAOs that operate in a certain period.

First, we need to define what means 'active' for both a DAO and a user. We will follow the definition in [11] that considers that a DAO or a user were active in a given month if at least they performed an action in that month. The available actions to be performed depend on the platform. For DAOstack we will consider the following activities as actions: to create a proposal, vote a proposal, and stake in a proposal. In the case of DAOhaus, we will consider: to create a proposal, vote a proposal, and quit a DAO. Finally, due to the customization of Aragon DAOs, it is difficult to homogenize the actions because of the multiple possible apps to install. So, in the case of Aragon we will just consider data, first from the basic Voting app (create a proposal[22] and cast a vote), and second from the Transaction app, used for donations or payments, where we will consider transactions as actions. However, for Aragon xDai actions, we can only consider data from the Transaction app because the API does not provide data from the Voting app in xDai. The approach followed may result in a highly conservative estimation in Aragon, where DAOs can be customized with different apps, and, hence, exhibit other types of activities.

Figure 3 shows that Aragon has the highest number of active DAOs, even considering the limitations mentioned, so the number of active DAOs should be higher. Still the number seems small (around 100) considering the number of DAOs registered (over 2,000 considering both mainnet and xDai). We can also observe a negative trend since May 2020.

DAOhaus apparently follows an increasing trend that also has benefited from the xDai network, greatly increasing its active DAOs to forty per month. Finally, the number of active DAOs in DAOstack is more modest (around 10) and xDai did not mean a sensible

[22] Proposals are known as "votes" in Aragon

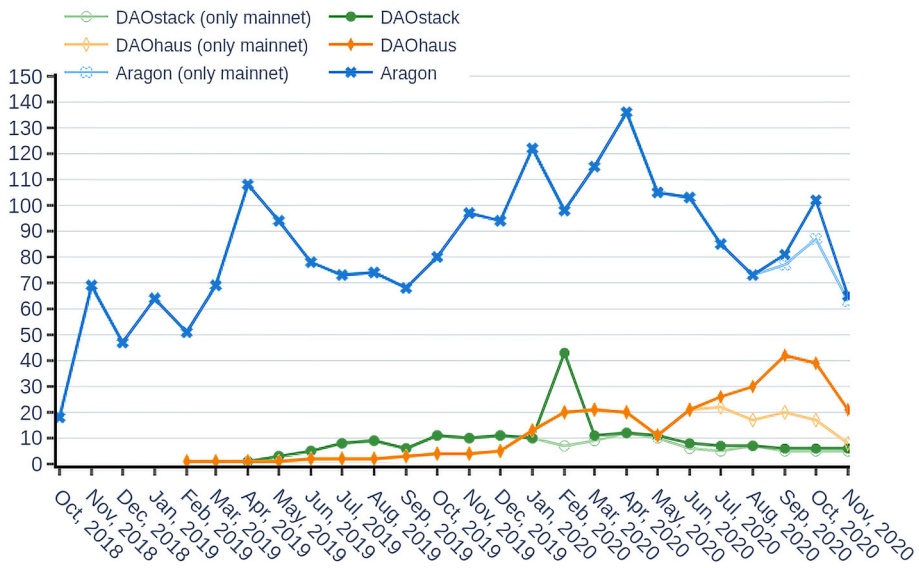

Fig. 3 Number of active DAOs in Aragon, DAOhaus and DAOstack, differentiating DAOs just in mainnet, and in both mainnet and xDai networks

increase. Still, it seems to remain stable during the last year and a half except for an activity surge in February 2020 due to the adoption of xDai.

Figure 4 shows the activity in terms of active users. Again Aragon has substantially higher number than the other two platforms. The number of active users is increasing, but the last three months show a volatile behavior. There is a peak in October 2020, which we believe it could be due to a migration to xDai.

While the number of active users in DAOhaus shows first an increase and then a decrease in the last few months, in DAOstack they have been decreasing since July 2019. According to this metric, the impact of xDai has not boosted the activity of DAO users.

4.3 Voting system

Arguably the most critical feature of DAOs is that they enable new models of governance. Internal processes and specially the decision-making processes typically rely on new instruments like tokens. The different decision-making methods explained in Section 3 such as holographic consensus, conviction voting, or dandelion voting, reflect a nascent diversity of options that are being both theoretically explored and experimented in practice within this field. Thus, studying the DAO voting systems renders crucial to understand the differences in the use of DAOs across platforms.

The three platforms considered are proposal driven, but each of them has their own governance and voting system, as explained in Section 3. In the case of Aragon, DAOs may have multiple voting systems. However, for the sake of simplicity, we just retrieved data from the standard voting app.

In order to compare these decision-making systems, we have chosen four metrics:

- The percentage of users who vote, which may enable us to observe the engagement of the DAO community.
- The number of cast votes per voter, which will show how active voters are in terms of participation.

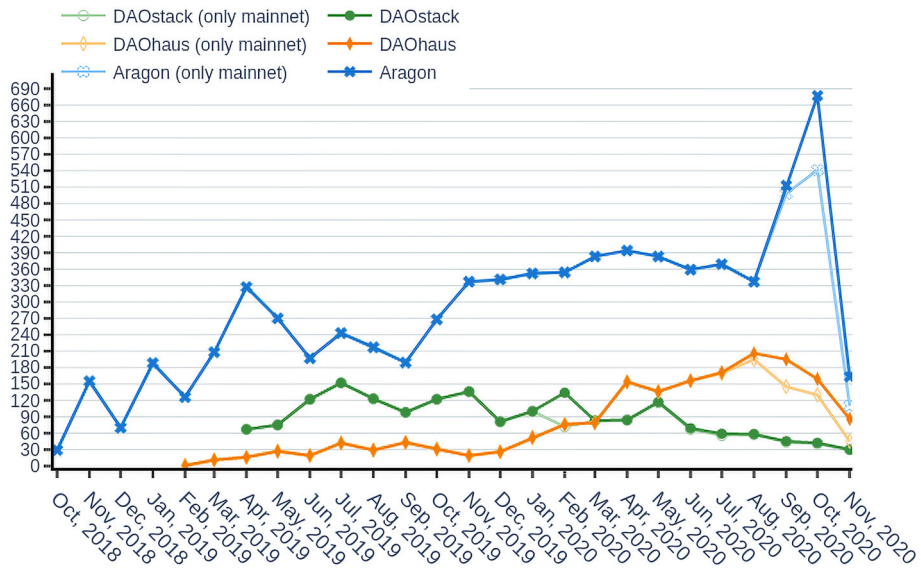

Fig. 4 Number of active users of the three platforms, differentiating users just in mainnet, and in both mainnet and xDai networks

- The percentage of proposals that are approved, which can show how the voting system may influence the results.
- The percentage of positive votes among those cast.

As we did for the previous metrics, we will consider both the mainnet and the xDai networks.

Table 3 shows the voting statistics for the three platforms. Interestingly, both in DAOstack and Aragon the percentage of users that vote is less than 10%, while in DAOhaus is close to 40%. In the case of DAOstack, the cause of such low percentage may be the inactivity of a DAO with around 4,000 users, while in the case of Aragon the high number of inactive DAOs. It is worth noting that the percentage of users who vote in xDai is smaller than in mainnet, even if it is cheaper to do so. A potential explanation may be that xDai is a younger alternative, specially in DAOhaus.

Regarding the ratio of votes per voter, in all the platforms has a value around 4. The main difference that we observe is that in DAOhaus the ratio in xDai almost doubles that in mainnet, which could mean that xDai boosted participation. In fact, according to Fig. 4, this effect cannot come from an increase of active users, since the number of active users in xDai decreased since the beginning of its adoption. Hence, it may correspond to an activity increase in the users that are active in xDai.

Table 3 Voting statistics by platform and network

	DAOstack			**DAOhaus**			**Aragon**		
	total	mainnet	xDai	total	mainnet	xDai	total	mainnet	xDai
Users who vote	4.5%	6.3%	2.1%	38.37%	39.5%	24.32%	-	6.18%	-
Votes per voter	4.6	4.64	3.64	4.26	3.96	7.28	-	4.08	-
Approved prop.	74%	74%	76%	92%	93%	87%	-	81%	-
Positive votes	86%	86%	95%	91%	90%	98%	-	94%	-

Regarding the percentages of approved proposals, the values are high for all platforms. It might be due to the fact that DAO members mainly present proposals that they believe that can be approved. This may respond to discussions held off-chain, before proposing on-chain. This behavior may also be a response to avoid the cost (in gas, reputation and time) of presenting proposals that are likely to be rejected. Still, there are important differences in the percentage of approved proposals across platforms. DAOstack has the lowest values (around 75%), followed by Aragon (81%) and then DAOhaus (around 90%). The different voting systems may cause such differences, we present our hypotheses below.

In the case of the DAOstack voting system, the lower number of proposals passed might be explained because it requires either an absolute majority (51%), or enough staking for a proposal to be "boosted" and thus able to be approved by relative majority. Thus, non-boosted proposals are more likely to be rejected. According to the analysis in [47], such behavior mainly happens in larger DAOs (those with more than 23 members), which are those that may have a greater need for holographic consensus to facilitate the approval of a proposal.

The high number of approved proposals in DAOhaus may be explained because the voting system requires no quorum, which makes proposals easier to be passed, since a relative majority is always enough to approve a proposal. Moreover, in DAOhaus v2, DAO proposals require a sponsorship of a community member, which acts as a preliminary filter of potentially rejectable proposals.

In the case of Aragon, we find a percentage of approved proposals between DAOstack and DAOhaus. Since the Aragon standard voting app requires a quorum to approve a proposal, it makes sense that the approval rate is below to that from DAOhaus. The aggregated results show that the Aragon voting system leads to lower rejection rates than the DAOstack system, which in some cases requires a majority voting to pass a proposal.

Note that we are not stating that a voting system is more effective than others, we are just interpreting the influence of those decision-making systems on the general figures. Nevertheless, our conclusions should be validated through further studies.

4.4 Funds

Given the importance of crypto assets within the blockchain ecosystem, studying the funds accumulated by each DAO is an essential aspect. In fact, one of the main features of DAOs is to enable collective management of funds through transparent open accounting. Multiple DAOs employ people or fund proposed projects that may benefit the community (e.g. programming or event organizing). And of course, given the rise of DeFi, DAOs are also being used to facilitate investment and financial operations.

In the following study, we focus on the DAOs accumulated cryptocurrencies. For that purpose, we have used the *DeepDAO* web service. However, DeepDAO does not provide information from all the DAOs in the considered ecosystems. Instead, it focuses on the most important ones and still covering a large number of them, and thus our analysis will rely on their available data.

Table 4 shows the Top 10 cryptocurrencies in terms of DAO adoption, that is, by the number of DAOs that use them. Ether and Dai are used by 50 and 51 DAOs, respectively, but Ether has more capitalization (close to 15 million dollars versus over 6 million dollars). Regarding the USD capitalization, it is important to bear in mind that the funds of a DAO

Table 4 Top 10 crypto-currencies by DAO adoption, including number of DAOs that use them, and the accumulated funds converted to USD, as of 1st December 2020

Token name	Token acronym	#DAOs	#USD in DAOs
Dai stablecoin	DAI	51	6,229,754$
Ether	ETH	50	14,714,446$
Sai stablecoin v1.0	SAI	21	15,013$
USD Coin	USDC	20	5,878,148$
Wrapped Ether	WETH	18	9,303,476$
Aragon	ANT	15	12,824,896$
Panvala pan	PAN	11	20,552$
DAOstack	GEN	9	37,553$
Tether USD	USDT	8	1,158,129$
Balancer	BAL	6	331,744$

are dynamic as it has inflows and outflows. The fund data was retrieved on the 1st of December 2020.

Interestingly, many of those crypto-currencies are *stablecoins* (DAI, SAI, USDC, or USDT). Stablecoins are designed to maintain a stable value, typically pegged to a fiat currency such as the dollar (e.g. 1 DAI = 1 dollar), to avoid volatile market periods and reduce transaction fees. We may split them into two groups. On one hand, the fiat-collateralized type (e.g. USDC, USDT) are the most common stablecoins, and they usually rely on centralized institutions. On the other hand, the case of the crypto-collateralized stablecoins (e.g. DAI, SAI) that do not depend on traditional finance infrastructure, and use crypto assets as collateral. For example, DAI and SAI cryptocurrencies are created by *MakerDAO*, a DAO created before the emergence of DAO platforms. Typically, in order to acquire these stablecoins, anyone may exchange Ethereum's cryptocurrency (ether) for them [53].

Ethereum's cryptocurrency, Ether (ETH), is one of the most used cryptocurrencies, despite its market volatility. However, not all DAOs can use ETH as an asset, especially because it does not comply with the popular Ethereum fungible token standard ERC20[23]. That is the case of DAOhaus's DAOs, which cannot use non-ERC20 cryptocurrencies. Due to that, there are solutions like WETH[24], that wraps ETH in an ERC20 smart contract.

There are other cryptocurrencies like ANT or GEN, which are specific tokens for Aragon and DAOstack ecosystems, respectively. The ANT token is used for the governance of the Aragon platform, while the GEN token is used in DAOstack's proposal boosting process. Besides that, some DAOs have their own crypto, for example, *PieDAO* has DOUGH, a coin with 44,291,262 USD of market capitalization, but owned only by this DAO.

Table 5 shows the Top 10 DAOs with more cryptofunds in USD. Most of those DAOs belong to the Aragon ecosystem. Interestingly, most of them have a small number of registered members (less than 10). We may describe some of these DAOs: *mStable*[25] is a DAO which provides autonomous and non-custodial stablecoin infrastructure to exchange stablecoins without additional fees. *PieDAO*[26] is focused on bringing market accessibility

[23] Ether was created before the ERC20 standard was established. The Ethereum community is currently working to update Ether to comply with their own standard.
[24] https://weth.io
[25] https://docs.mstable.org/
[26] https://docs.piedao.org/

Table 5 Top 10 DAOs by a total of cryptocurrencies in USD, as of 1st December2020

DAO name	DAO platform	#Funds in USD	#Members
PieDAO	Aragon	73,829,906$	2,881
mStable	Aragon	38,263,266$	8
dxDAO	DAOstack	17,581,208$	444
Airalab	Aragon	13,263,696$	11
Aragon Trust	Aragon	7,015,477$	5
Aragon Network Budget	Aragon	5,903,309$	3
MetaCartel Ventures	DAOhaus	5,619,718$	99
Aavegotchi	Aragon	5,059,662$	3
API3 DAOv1	Aragon	2,991,833$	30
Aragon Network	Aragon	2,932,121$	5

and economic empowerment, facilitating the automation of tokenized "wealth creation" strategies (e.g. profitable investments). In the case of *dxDAO*[27], it is a DAOstack DAO that obtains revenues from its DeFi services they have and/or develop. *MetaCartel Ventures*[28] is a for-profit DAOhaus DAO created for investing into early-stage Decentralized Applications (DApps).

5 Discussion

We have compared the three main DAO ecosystems using four dimensions: growth, activity, voting, and funds. According to our quantitative analysis, Aragon is clearly the largest and most active platform. Still, the difference with the other platforms is significantly less than what a superficial exploration may indicate. The initial DAO numbers, which are typically observed (and advertised) for each platform (shown in Table 2), would reveal that the size of Aragon is a 10 times larger than DAOhaus and a 79 times larger than DAOstack. However, from its 1,700+ DAOs (2,000+ including xDai DAOs) and 41,000+ users (68,000 including xDai), Aragon has just 100 DAOs and 330 users which are active each month. This is noteworthy, since the gap across platforms in practice, counting only active DAOs and active users, is significantly smaller. Thus, according to active DAOs, Aragon is 3 times more active than DAOhaus, and 11 times than DAOstack; according to active users, Aragon is 27 times more active than DAOhaus, and 5 than DAOstack.

Still, this does not diminish the Aragon platform in any way. The participation of a minority of a community and the abandonment of the project, it is typical in online communities such as wikis [52, 54, 55], and it seems that this aspect also holds for the case of DAOs. Besides, Aragon shows a steady growth in the number of DAOs, at least an order of magnitude higher than the other platforms. Moreover, eight of the top ten wealthiest DAOs rely on the Aragon platform. And its ability for customizing DAOs may reveal essential to exploit the potential of DAOs [4]. Still, since May 2020 we can observe a decline in the number of active DAOs within Aragon, which is worth more research.

Concerning DAOhaus, it has shown a clear and steady growth in the last months analyzed, in number of DAOs, active DAOs and user activity. Its voting system seems to be the easiest to approve a proposal, reaching a surprising 92% of proposals passed. Despite of DAOhaus being born recently, in 2019 [56], it has managed to position itself as an active platform with positive trends.

[27] https://dxdao.eth.link/#/faq
[28] https://metacartel.xyz/about

Concerning DAOstack, the numbers of activity and adoption show signs of stagnation, even after the adoption of xDai. A potential explanation may be the problems in Genesis DAO, a DAO dedicated to promote the use of DAOs through DAOstack [11]. Still, some of its communities remain loyal and active, including the third wealthiest DAOs overall, *dxDAO*. It is worth noting that DAOstack has more DAOs in xDai than in mainnet, which may facilitate a venue of recent growth which we could not monitor in Fig. 1 (due to API limitations, as explained in Section 4.1).

Due to the surges in gas price during 2020, the platforms facilitated the possibility to operate in the xDai network. However, our analysis does not show a strong effect on the platform's activity, as we may have expected. In any case, xDai solutions are temporary solutions until the arrival of Ethereum 2.0, which is expected to clearly mitigate the problems of gas cost.

6 Concluding remarks

In this work we have reviewed the three main platforms that nowadays facilitate the creation and management of DAOs: Aragon, DAOstack, DAOhaus. For such comparison, we retrieve data from both the main Ethereum network (*mainnet*) and a parallel Ethereum network (sidechain *xDai*). We analyze data from 72,320 users and 2,353 DAO communities in order to study the three ecosystems across four dimensions: growth, activity, voting and funds. Our results, discussed in Section 5, show that there are notable differences across the DAO platforms in terms of growth, activity, and voting results.

In general, we need to remark that the conclusions drawn from the retrieved statistics must be taken with caution. First, because we are looking at general statistics (counts, rates and general trends) without looking into the individual communities. Given the current relatively small number of DAOs and the diversity of DAOs, these figures may be misleading in some cases. Second, because the figures reflect the activity of the early-adopters interacting with a new technology. Thus, in some cases, some of these early adopters may have already abandoned the technology, or are using it purely for testing their capabilities.

We believe that further research could explore this phenomenon both quantitatively and qualitatively, deepening into some of the open questions extracted from this work, such as the current decline in Aragon active DAOs, its volatile active user numbers in recent months, the very high percentage of passed proposals in DAOhaus (and relatively, also in the other platforms), or the reasons behind the xDai growth in DAOstack.

Despite these shortcomings, we believe it is necessary to advance in the understanding of this new form of online organization that it is taking shape in the blockchain and that is implementing innovative forms of governance. The people that design DAO mechanisms often do it without prior extensive testing. Thus, as a result, these first organizations can be seen as guinea pigs that are experimenting with a novel system for the first time, while at the same time being the object of the experiment. Furthermore, these new organizations are strongly influenced by the underlying technology, a costly, append-only, decentralized and transparent database. Hence, their collective behavior could be different to organizations that operate through standard client-server applications deployed on the Internet.

All these aspects make DAOs a challenging research field. We particularly consider important to dive into the voting systems and how they are affected by aspects such

as accumulated funds, reputation, etc. We hope our article stimulates the research on these novel communities to help them deliver truly effective decentralized and scalable collective governance.

Appendix: data collection process

All data from the studied DAO platforms is publicly available in the Ethereum's blockchain (and its sidechain xDai). However, the process to fetch and query this data is rather tedious, since the data is stored as transactions in the ledger. In order to ease the query process, different solutions have came out. For our purposes we have used *The Graph*.[29] *The Graph* is a protocol which indexes blockchain data in order to facilitate database queries. Its use is popularizing across Ethereum Dapps which may use it to facilitating making their data available. The data is served as an API, and it is fetched with the *GraphQL* language.[30] This is the case for the three DAO platforms we have analyzed, providing APIs using *The Graph*. DAOstack,[31] and DAOhaus[32] offer all their ecosystem data through the same endpoint for each. However, Aragon offers an endpoint for each app it has, and thus we have used different endpoints for the voting,[33] DAOs,[34] or tokens.[35]

Abbreviations

Dapp: Decentralized application; DAO: Decentralized Autonomous Organizations; DeFi: Decentralized Finance; CV: Conviction Voting; HC: Holographic Consensus; USD: United States Dollar ($); ETH: Ether, Ethereum's cryptocurrency; SDK: Software Development Kit; DApps: Decentralized Applications

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Authors' contributions

YFR carried out the research, retrieving and analyzing the data metrics for the DAO comparison and implementing those metrics in DAO-Analyzer. He also wrote the first draft of the manuscript. JA planned and supervised the research, analyzed the data and co-wrote the introduction, the quantitative comparison and the discussion section. SH planned the research, reviewed, and rewrote all sections of the manuscript. All authors read and approved the final manuscript.

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Availability of data and materials

The datasets generated and/or analysed during the current study are available in the following GitHub repository, https://github.com/Grasia/DAO-comparison-data. Most of such data was extracted from the DAO-Analyzer web tool, with its open-licensed code available in the GitHub repository https://github.com/Grasia/dao-analyzer, and deployed in http://dao-analyzer.science/. The data concerning cryptocurrency funds was extracted from the DeepDAO web tool, http://deepdao.world. Its source code is proprietary and therefore not publicly available.

Declarations

Competing interests

The authors declare that they have no competing interests.

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[29] https://thegraph.com/
[30] https://graphql.org/
[31] https://thegraph.com/explorer/subgraph/daostack/master
[32] https://thegraph.com/explorer/subgraph/odyssy-automaton/daohaus
[33] https://thegraph.com/explorer/subgraph/aragon/aragon-voting-mainnet
[34] https://thegraph.com/explorer/subgraph/aragon/aragon-mainnet
[35] https://thegraph.com/explorer/subgraph/aragon/aragon-tokens-mainnet

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