A Categorization of Decentralized Autonomous Organizations: The Case of the Aragon Platform

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***Abstract*— The advent of blockchain technology has paved the way for numerous innovations in online governance, with decentralized autonomous organizations (DAOs) emerging as a prominent development, often referred to as "digital jurisdictions." Despite experiencing remarkable growth, currently boasting nearly 7M users and $18 billion in assets, DAOs remain relatively underexplored in the existing literature, particularly from an empirical perspective. This study presents a comprehensive framework comprising 15 dimensions to categorize DAOs based on their operational domain, purpose, scope, voting process, and utilization of crypto-tokens. By applying this categorization schema to 40 DAO communities hosted on the Aragon platform, encompassing over 423 000 participants and managing treasuries worth $960M, we shed light on the prevailing characteristics of these DAOs. Contrary to assertions made by blockchain enthusiasts, our analysis reveals that DAOs predominantly operate in financial and technological domains, primarily offering blockchain-based services. Additionally, our investigation into their governance structure exposes limitations in terms of democratic participation, as decision-making power typically correlates with the number of tokens owned by the voter, resembling plutocracies rather than true democracies. We believe these findings will facilitate researchers' comprehension of this innovative form of governance and aid practitioners in designing future DAOs with greater effectiveness. Furthermore, our analysis can be replicated on other platforms or at different time periods to validate and contrast our conclusions.**

***Index Terms*— Aragon, archetypes, blockchain, cryptocurrencies, decentralized autonomous organizations (DAOs), governance, online communities, tokens, voting system, web3.**

I. Introduction

BLOCKCHAIN technology has brought a paradigm shift in developing decentralized systems, applied to multiple sectors [1]. In particular, in online governance, blockchain facilitates the development of transparent decision processes, tokenization, formalization of rules, automation, and an alleged decentralization of power [2]. In fact, blockchain enthusiasts' narratives [3] claim we can now create the "first digital jurisdictions" [4], and even "Internet nation states" [5]. This is made possible through the emergence of a new kind of online community: the so-called decentralized autonomous organizations (DAOs).

According to formal definitions [6], [7], a DAO enables people to coordinate and self-govern themselves mediated by a set of self-executing rules deployed on a public blockchain, where governance is independent of central control. Empirically, a DAO consists of individuals with a shared objective who may utilize "governance tokens" to participate in the decision-making process of the DAO, often through a voting system. These tokens can possess both monetary value (e.g., cryptocurrencies) and represent voting power, permissions, or reputation. DAOs typically manage crypto-assets, such as cryptocurrencies, and their members propose how to allocate these assets through proposals that align with the collective interest. These proposals may involve decisions related to the project the DAO is undertaking. DAOs combine characteristics from open-source communities [8], [9] and more traditional organizations or enterprises [10], yet they differ from both.

In the last few years, the adoption of DAOs has increased spectacularly: as of July 2023, 7M DAO members are managing $21 billion in crypto-assets within 13 000 DAOs.[1]

The rise of several DAO-as-a-service platforms in recent years has facilitated this rapid growth. These platforms simplify the deployment of DAOs on public blockchains by offering customizable templates that empower users to create their own DAO. They enhance community interactions and reduce the technical expertise required to operate a DAO. While platforms like DAOstack or Colony initially garnered attention, they have since experienced stagnation or slowed growth. Conversely, platforms like DAOhaus, which employ a straightforward governance approach, have witnessed rapid expansion, with over 900 DAOs currently active.[2] The field is highly dynamic, and new DAO tools continue to emerge. Examples include Snapshot (an OFF-chain voting platform for DAOs), Gnosis Safe (for collective crypto-asset management), Coordinape (for resource distribution to contributors), and DaoLens (to facilitate contribution to DAOs), among others.

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[1]Data from DeepDAO https://deepdao.io

[2]Data from https://app.daohaus.club/explore

In the literature, researchers have explored the general capabilities of DAOs [11], [12], governance challenges [13], [14], task management strategies [15], and privacy issues [16]. Research efforts have primarily focused on quantitatively characterizing the phenomenon, including the adoption and overall level of activity of DAOs [17], [18], often examining specific platforms [19], [20], or analyzing the state and evolution of individual DAOs [21], [22]. In terms of qualitative characterization, most studies have analyzed the case of a single DAO [13], [23] or a small number of them [24] with qualitative methods.

These efforts explain either the magnitude of the DAO phenomenon overall, or the in-depth cases of particular DAOs. However, they do not offer empirical answers to mid-scope matters like the main trends in DAOs in terms of their purpose, scope, governance system, or how their tokens are used. This is precisely the aim of this article, tackling the research question ***what kinds of communities emerge from the current uses of DAOs?***

To address this question, we have conducted an empirically grounded systematization effort to categorize the different types of DAOs in the field. We will focus on a specific DAO-as-a-service platform: Aragon, which emerged intending to enable the "first digital jurisdictions" [4]. Aragon has evolved into one of the largest DAO platforms, with 5k DAOs, which allocate about $6B in crypto-assets. In March 2023, coming back to its original aim [25], Aragon merged with the Nation3 project. Nation3 claims to be "A new nation-state on the cloud: Online-first, zero-tax nation with its own jurisdiction, court, and system of law."

For our systematization effort, we first define a scheme for describing the DAOs focusing on general aspects such as their purpose, domain, scope, voting system, or operative tokens. Then, we qualitatively characterized 40 DAO communities within the Aragon platform, across 15 dimensions, i.e., variables. Our DAO sample includes more than 423k participants, with DAO treasuries holding $960M, using 60 different tokens. The categorization results were analyzed using visualization and statistical tools to identify recurring patterns in the annotated categories and eventually define archetypes. The archetypes aim to provide qualitative descriptions of how DAOs are currently used in Aragon.

Consequently, our work makes two primary contributions. First, we propose a categorization scheme that offers a qualitative description of DAOs, encompassing their voting systems and tokens. Second, we identify archetypes representing distinct types of DAOs currently observed within the Aragon platform. Additionally, the methodology employed can be replicated to investigate DAOs across different time periods or on alternative platforms.

In the rest of the article Section II deepens on what DAOs are, their evolution, and their challenges, while Section III discusses the related work. Then we present methodological aspects in Section IV and the DAO archetypes resulting from our study in Section V. A discussion is presented in Section VI. Finally, Section VII includes the concluding remarks and presents ideas for future works.

II. Overview of the Evolution of DAOs

In a DAO, governance is implemented as blockchain code, which facilitates, among others, automation, decentralization, and transparency [2]. Developing such code requires highly specialized technical knowledge, and even so, the result is not free of problems. A notable example was *The DAO*, one of the first attempts to build an exemplary DAO but which was hacked later on [23]. Despite this event, other early DAOs were successful, such as Moloch DAO, which granted funds to develop the famous Ethereum 2.0 project, and Maker DAO, which created and automatically managed a cryptocurrency whose value was not volatile (the stablecoin DAI).

Besides the case of particular organizations, several software platforms are offered to facilitate the deployment and operation of DAOs without requiring programming skills. They have contributed to increase the popularity of DAOs. Some of these pioneering platforms are Aragon, DAOstack, and DAOhaus. Each platform provides a software infrastructure that allows the configuration of functionalities, like the voting system, and even the possibility to extend the functionality of DAOs beyond voting and fund allocation.

The capabilities and limitations of DAOs are tied to those of blockchain technology. For example, operating through a DAO costs more than other online communities. DAOs are usually deployed in public blockchains like Ethereum, which implies that even if there are no monthly hosting fees as in traditional server-centric webpages, users requesting an operation must compensate the peer-to-peer network for doing the computational work. Thus, DAO operations require a micro-payment by the requester, and the cost depends on the network demands. When the cost is high, it may impact the DAO activity. This happened when the Ethereum computation prices spiked in 2020 after the success of Decentralized Finance applications [26]. As a result, most DAO platforms enable the deployment of "sidechains," independent and cost-effective blockchains that are interoperable and connected to mainchains, such as Ethereum (e.g., the Ethereum's sidechains Arbitrum, Polygon, or Gnosis Chain, formerly xDAI). Other DAO platforms, such as Snapshot, offer the possibility to vote OFF-chain (i.e., outside of a blockchain) using web applications and then consolidate the vote results on the blockchain. Not only does the low maturity level of blockchain technology impacts DAOs nowadays, but the high entry barrier imposed by their user interfaces may hinder their adoption [27], [28].

Besides the limitations mentioned above and the niche nature of blockchain technology, the numbers denote a high DAO penetration, which showed to manage impressive sums of crypto-funds. All these aspects make DAOs a new kind of online community that deserves more attention from academic scholars in general and the computational social systems community, in particular, to better understand the phenomenon, improving their design by addressing their challenges.

III. Related Work

A. Research on Decentralized Autonomous Organizations

Due to the brief history of DAOs, with Ethereum first released in 2015 and the first DAOs dating from 2016, the

research literature has not explored this phenomenon as profoundly as other online communities. Still, conceptual aspects of DAOs, like governance [14], [15], [29], [30], privacy and security [16], [31], or taxation [32], have been examined through particular case studies.

The potential application of DAOs in different domains has also started to be explored. The *Decentralized Autonomous Space* was introduced as a DAO linked to a physical location and operated by smart contracts [33]. Likewise, *LikeStarter* is a decentralized application that combines social interactions with crowdfunding, facilitating investing through tokens [34]. Along this line, a DAO equipped with Artificial Intelligence was built as an art organization that sells art created by a neural network [35]. Following the practical application of DAOs, the use of a DAO for an e-government service was demonstrated, highlighting the main difficulties in data integrity, confidentiality, and rules integrity [13].

Regarding the characterization of the use of DAOs, a comparative analysis of the software platforms proposed to facilitate the deployment of DAOs was conducted [17]. In the same article, the authors quantitatively described aspects like growth, activity, voting, and funds of the DAOs living on *Aragon*, *DAOhaus*, and *DAOstack*. Similarly, in [18], the authors retrieve data from DAO-analyzer [22], CoinMarketCap[3] and Snapshot to assess the growth of DAOs, and study their tokens and their proposals. Other works have quantitatively analyzed in depth the use of a specific DAO platform, such as DAOstack or Snapshot, to study its voting systems [19], [20].

Despite these descriptive quantitative efforts, the state-of-the-art lacks empirically grounded systematization efforts to categorize the different types of DAOs. This study aims to fill this gap by proposing an approach to qualitatively characterize the operational, governance, and financial aspects of DAOs.

B. Characterization of Online Communities

Online communities are increasingly permeating numerous aspects of our daily lives, from asking for support in a specialized forum to mediating our daily work practices [36]. The nature and overall purpose change from community to community, and there have been academic efforts to study and characterize them systematically and empirically [37]. In this sense, several typologies have been proposed to classify online communities.

Two influential works have contributed significantly to their classification and characterization. Porter [38] introduced a system for categorizing online communities based on whether they are sponsored by an organization or initiated by an individual, as well as the type of relationship among community members, such as social, professional, or commercial connections. Armstrong and Hagel [39] classified online communities into four categories:*communities of interest*, based on shared interests, *communities of relationship*, based on social relations, *communities of transaction*, based on economic exchange, and *communities of fantasy*, based on environments/personalities developed in virtual worlds.

Beyond general schemes to classify online communities, scholars have also focused on particular types of online communities and studied their characteristics. This is the case of Saldivar et al. [40] who studied innovation communities, using exploratory data analysis, visualization techniques, and clustering tools to identify patterns that characterize these communities. Similarly, it was proposed an approach that combines quantitative and qualitative methods (surveys, descriptive statistics, social network analysis, text mining) to explore the organizational structure, shared goals, vocabulary sharing, and user interactions of an online music-sharing community [41]. Along this line, Soliman et al. [42] worked on characterizing political communities on Reddit after analyzing through content analysis (frequently used words, shared links) and descriptive statistics, a dataset of more than 100M posts and 5M users. In particular, they analyzed the content posted, the language used, the attention received, and the connection between subcommunities. Open-source software (OSS) communities were classified in [43]. Here, the authors suggest that OSS communities can be either *exploration-oriented*, *utility-oriented*, or *service-oriented*, depending on their structure and the role of their members.

Besides the exhaustive taxonomy to characterize blockchain networks, protocols, distributed ledgers, tokens, and digital wallets presented in [44], there is a lack of empirical studies that systematically examine blockchain-based online communities. Regardless of methodological similarities with previous work (e.g., [40], [41]), to the best of our knowledge, this study is the first attempt to develop an approach through which DAOs, can be classified, characterizing their operative, financial, and governance aspects.

There have been some preliminary attempts at categorizing DAOs within the industry. Specifically, the blockchain startups DeepDAO and Messari provide some basic characterizations. DeepDao has a set of 12 topic-based categories to enable basic filtering of its DAO database. These categories are not exclusive, e.g., the DAO Decentraland is tagged with both "Gaming" and "non-fungible tokens (NFTs)" labels. Moreover, when accessing a specific DAO, it is not available how it has been labeled. Messari follows a similar approach, with nine "types" and 24 "tags" to label DAOs, again non-exclusively. They help differentiate DAOs based on their topic (e.g., "metaverse" or "gaming") or by describing specific characteristics (e.g., "has NFTs"). Our approach aims to build archetypes and a complex classification rather than merely using labels for filtering purposes.

IV. Methods

A. Aragon, the Platform of Interest

To address the research question, we conducted a qualitative analysis of a sample of DAOs from the Aragon platform. We decided to employ Aragon because it is one of today's most used frameworks to build a DAO, which allegedly holds more than 5000 DAO communities, according to Aragon's website.[4] Another highlighted aspect of the Aragon framework is its greater flexibility to set up a DAO, in comparison to

[3]A website that provides financial information on cryptocurrencies.

[4]See http://aragon.org

TABLE I
GENERAL SCHEME DEVELOPED TO CODE DAOS

Dimension	Value	Definition
Active	*Whether the DAO is active or not at the moment of the coding process*	
	Yes	There is evidence of at least one transaction (token or vote), activity on social media, or GitHub commits in the last month
	No	There is not available evidence of transactions, social media activity, or GitHub commits in the last month
Domain	*Domain in which the DAO operates*	
	Social	Social cause supporting
	Technology	Software and hardware development
	Finance	Services such as banking, trading, investing, lending, advising, managing assets
	Other	Other domain such as Legal, Education, Entertainment, Arts
Purpose	*Primary reason for running the DAO*	
	Granting	The DAO is used to channel donations to fund projects. They either directly collect funds or develop tools to fundraise and then use the DAO to make decisions
	Service	The DAO provides services or goods (physical or digital) such as entertainment, artistic, programming, legal, financial, etc.
	Peer-production	The DAO is used by people of aligned interests to meet and share information as well as to create, distribute, and monetize content.
	Other	Related to other purposes not described above
Scope	*Main subject matter of the DAO (non-exclusive dimension, i.e., more than one value can be assigned)*	
	Blockchain	Related to blockchain technology (e.g., cryptocurrencies, NFTs, dApps)
	Web 2.0	Related to Web 2.0 technology (e.g., ordinary webs, centralized applications)
	Physical	Related to the physical world in terms of buying goods, providing services, managing locations, etc.
	Other	Related to other scopes not mentioned above
Community size	*Number of members registered on the DAO at the moment of the coding process*	
	Small	One to 100 registered members
	Medium	101 to 1000 registered members
	Large	1001 one to 10000 registered members
	Extra large	More than 10000 registered members
Treasury	*Total amount of cryptocurrencies in USD managed by the DAO at the moment of the coding process*	
	Small	Zero to 1 million USD
	Medium	More than 1 million USD and up to 10 million USD
	Large	More than 10 million USD and up to 100 million USD
	Extra large	More than 100 million USD

other DAO platforms, such as DAOstack or DAOhaus, whose features and governance mechanisms are more limited.

Aragon offers organization templates that can be customized through predefined applications that provide functionalities like financial management and decision-making. Besides, Aragon's functionalities can be extended via specially developed applications implemented on top of its infrastructure by concatenating the operation of smart contracts. We understand that this flexibility should favor the diversity of the Aragon ecosystem, enriching our study.

B. Sample Selection

To ensure a reproducible and objective selection process, our aim was to carefully choose a sample of DAOs. We discovered a section on Aragon's website that presents a curated list of DAOs as exemplary cases of blockchain-based communities utilizing their platform. However, it should be noted that Aragon's criteria for featuring DAOs on their website is not explicitly documented, which introduces the possibility of bias in our analysis. Our results may be influenced by a bias toward DAOs that have achieved high visibility and maturity, as they are more likely to be highlighted as successful cases on Aragon's website. Nonetheless, given the limitations of random sampling, which may result in DAOs with low activity and limited traceable information, we deemed this approach as the best option to meet our requirements.

Initially, our sample of interest comprised the 42 DAOs showcased on the community section of Aragon's website as of February 2022.[5] However, following the coding process outlined below, we decided to exclude two DAOs from our analysis. The first one, *Aragon China*, was excluded due to a lack of available traceable information. The second DAO, *Cyber Foundation*, was deemed a duplicate of *Cyber Congress*, which was included in the final set of DAOs. Consequently, our study sample comprises a total of 40 DAOs.

[5]See https://poweredby.aragon.org/#communities

C. Coding Scheme Definition

To analyze the selected sample of DAOs, we employed a systematic procedure to develop a coding scheme. In the initial step, one of the coders, coauthor of this article, examined a random subset of ten DAOs from our sample. This examination was conducted using an open coding method, which is a qualitative data analysis technique that allows for the identification of emergent patterns without predefined categories or labels [45], [46]. Then, the coder shared the findings with the other authors, and together, they established a baseline coding scheme consisting of six descriptive dimensions: "active," "domain," "purpose," "scope," "community size," and "treasury." Each dimension was restricted to predefined values. For instance, under the "purpose" dimension, the coder could assign one of the following values: "granting," "service," "peer-production," or "other," where the latter refers to alternative values not covered in the scheme. Table I presents an overview of the coding scheme, including the dimensions, values, and definitions.

We also collected raw data about the DAOs' community size and treasury at annotation time. For these two dimensions, we took the values reported by the DAOs in their sites; if no value was available for a dimension, we used the one provided

TABLE II
SCHEME DEVELOPED TO CAPTURE ASPECTS OF THE DAOS' VOTING PROCESSES

Dimension	Value	Definition
Participation	*Who can participate in the decision-making process*	
	Universal	All the members of the DAO have rights to vote
	Restricted	Voting right depends on meeting certain conditions
Vote weight	*Whether votes have the same weight or not*	
	Uniform	Votes have the same weight
	Tokens owned	Vote weight depends on the number of tokens owned by members, the more tokens the more voting power the member has
	Tokens deposited	Vote weight depends on the number of tokens deposited on a proposal
	Tokens deposited and time locked up	Vote weight depends on the number of tokens deposited on a proposal and the time these tokens are locked up
	Other	Related to weights not mentioned above
Vote cost	*Whether voting demands losing the deposited tokens*	
	Yes	The voter loses the deposited tokens when voting
	No	Voting either does not involve depositing tokens or the tokens get back to their owner once the voting finishes

TABLE III
SCHEME DEVELOPED TO CODE TOKENS USED IN DAOS

Dimension	Value	Definition
Utility	*The utility of the token on the DAO (non-exclusive dimension)*	
	Financial	The token is used for financial purposes (e.g., payment, staking)
	Usage	The token provides access to services offered by the DAO (e.g. software, advising, etc)
	Governance	The token allows voting rights within the DAO
	Reputational	The token is linked to the reputation of the members
	Reward	The token is used to motivate activities of interest for the DAO
	Membership	The token is used to represent a sense of belonging to the DAO
	Other	Related to utilities not captured by the values above
Issuance	*How the token is assigned to members of the DAO (non-exclusive dimension)*	
	Contribution	The token is obtained after participating in or contributing to a DAO through software development, content production, voting, participation on social media or grants programs
	Purchase	The token is acquired through a normal buying process
	Acquired rights	The token is given by acquired rights (e.g., founders of the DAO)
Total supply	*How is determined the supply of the token*	
	Fixed	The maximum amount of tokens that will ever exist is defined when it is created
	Conditional	The total supply of the token depends on predefined conditions
	Adjustable	The total supply of the token is set from time to time by authorized parties of the DAO
Fungible	*Wether the token can be replaced by another one, meaning they are indistinguishable*	
	Yes	The token is fungible
	No	The token is not fungible
Transferable	*Whether the token can be transferred to another member of the DAO or not*	
	Yes	The token is transferable
	No	The token is not transferable
Monetary value	*Whether the token has monetary value or not*	
	Yes	The token price appears listed in coinmarketcap.com
	No	The token price does not appear in coinmarketcap.com

by DeepDAO. Given that these two dimensions are numerical, their ranges of values were divided into predefined categories following a logarithmic scale. The logarithmic bins were used because they provide a compact and understandable way to summarize data that exhibits a wide range of values. The categories and their respective ranges are shown in Table I.

The number of DAO members is an estimation. A member is identified by her wallet address, i.e., a unique public address for transfers. However, a member can possess multiple wallets, and multiple individuals can share a single wallet. Thus, by "members," we actually refer to the count of wallet addresses.

While developing the scheme in Table I, we realized that a single dimension was not enough to cover the complexity of the DAOs' voting procedures, which depend on several aspects, like having open or restricted participation or having a uniform or concentrated distribution of power. Thus, we decided to define a separate scheme to study this topic. Table II shows the DAOs' voting scheme. The process followed to create the voting scheme was identical to the method of the general scheme, meaning, the same coauthor manually code the same sample of ten DAOs employing open coding. Then, results were shared among authors, who agreed on the dimensions and values.

To study how the tokens are used by DAOs in their internal operation, we proceeded in a similar manner. Given that we found that their characteristics are sophisticated enough, we decided to analyze them using a particular scheme. The tokenized nature of DAO activity and aspects such as the token utility, supply, or issuance, to name a few, can take different forms under distinct circumstances, which demand using a specific scheme to study them. Table III displays the scheme we used to classify the tokens of DAOs.

The definition of the coding schemes was validated by an expert in DAOs, a coauthor of this article. The expert reviewed the schemes to ensure coherence and completeness and the coders fixed the schemes accordingly. The review consisted in checking that there were no omitted aspects or ambiguities or overlaps in the dimensions or their values.

TABLE IV
INTER-CODERS AGREEMENT BY DIMENSION AND SCHEME

General		Voting		Tokens	
Dimension	Agreement	Dimension	Agreement	Dimension	Agreement
1. Active	100.00%	1. Participation	86.79%	1. Utility	79.49%
2. Domain	92.84%	2. Vote weight	100.00%	2. Issuance	82.05%
3. Purpose	89.47%	3. Vote cost	100.00%	3. Supply	77.98%
4. Scope	95.80%			4. Fungible	90.07%
				5. Transferable	89.41%
				6. Monetary value	94.76%
Average	94.53%	***Average***	95.60%	***Average***	85.63%

D. Coding Process

For each DAO, the content analyzed included the DAO's site on Aragon, particularly the voting section that lists the proposals voted by the community. Also, we studied the DAO's website, white paper, Discord, Discourse forum, wikis, and social media channels (e.g., Twitter, Telegram, LinkedIn and Medium), and, if available, its Github profile.[6] The information provided by the DAOs on these sites was assumed to be true and "official," even if contradictory data could be found elsewhere on the web.

Once the data sources were defined, two independent coders, i.e., the coder that conducted the initial exploration of the random sample of DAOs and an additional coder who was not the expert that validated the coding scheme, categorized the 40 DAOs using the defined schemes (general, voting and tokens). Specifically, they went through the data sources listed above, looking for information that helped them decide which value to assign to each category of the coding schemes. If no information was found, the coders explicitly indicated the situation. Agreement was not calculated for "community size" and "treasury" dimensions of the general scheme as they encompass objective (numerical) data, leaving no room for subjective or ambiguous interpretation.

When the coders finished categorizing the DAOs, a third person—a coauthor of this article but not the expert who validated the schemes—computed the inter-coder agreement using Krippendorff's alpha method [47], which quantifies the inter-coder agreement, offering a measure of the consistency of coding decisions. In case of disagreements, the two independent coders met and agreed on a common value. When coders could not reach a consensus, a third party (the coauthor who validated the schemes) mediated the conflict helping the coders to find an agreement. The final inter-coder agreement for the three schemes was 91.92%. Table IV details the inter-coders agreement by dimensions and categories. The largest number of disagreements occurred when encoding tokens because of the ambiguity of the information available. Still, in all cases, they reached reliable scores surpassing the minimum acceptable agreement score of 66% [47], not only in all the schemes but in every single dimension, as seen in Table IV.

E. Dataset Preparation

The final datasets were pre-processed by computing and assigning labels to the dimensions "community size" and "treasury" and by removing the data of the discarded DAOs (see Section IV-B). Then, data was prepared following the tidy data format [48]. In this structure, variables are columns, and observations are rows. Non-exclusive variables are mapped to as many columns as the number of different values the variables can take. For example, a non-exclusive variable with five values is mapped to five columns, each one having Boolean values (True/False) indicating whether the variable takes the value represented by the column or not.

The annotations of the general scheme were transformed into a dataset where columns correspond to the dimensions while cases (DAOs) were stored in rows. The dimensions active, domain, purpose, community size, and treasury have a column each. In contrast, the dimension scope, which is non-exclusive, was represented using four columns, one per possible value. Likewise, the annotations of the voting and token schemes were stored in tidy datasets. The three datasets are available for further analyses at IEEE DataPort (https://dx.doi.org/10.21227/pxft-3480).

F. Dataset Analyses

The datasets were analyzed using several statistical methods. First, we computed descriptive statistics to overview the different variables. Then, following the approach proposed by [40], the annotations were examined using graphical analytics tools, like Alluvial Chart [49], to find emerging archetypes, i.e., groups of DAOs where tuples of values tend to co-occur frequently among the dimensions. We took a different approach for tokens because of having a larger dataset (i.e., 60 tokens versus 40 DAOs) and multiple combinations derived from the non-exclusive categories. We used the non-supervised K-means clustering algorithm [50], [51] to group tokens according to similarities in the annotation of their features (i.e., utility, issuance, supply, fungible, transferable, and monetary value). Before running the K-means algorithm, the categorical features were transformed into numerical variables using one-hot encoding[7] [52]. We tested the algorithm iteratively with different numbers of clusters until we were satisfied with the grouping. The satisfaction criteria employed has been the interpretability of the resulting clusters, prioritizing its ability to be effectively understood. Finally, we checked whether significant associations existed between archetypes (or clusters) of the three coding schemes. We used the Fisher's exact test [53], which tests an association between two categorical variables and is recommended for small sample sizes like ours. When the association turned out statistically significant according to the test, we inspected the standardized Pearson residuals [54] to check which two archetypes have a co-occurrence significantly greater or smaller than expected. Thus, we uncover underlying relationships across the schemes in the DAO sample.

[6]See for example https://client.aragon.org/#/1hive, https://about.1hive.org/docs/dao, https://discord.gg/XNcF2vD, https://forum.1hive.org, https://wiki.1hive.org/developers/1hive-protocol or https://github.com/1Hive respectively.

[7]In one-hot encoding each distinct value of a categorical variable is transformed into a binary variable to indicate the value's absence or presence.

V. Results

A. Summary Statistics of the Dataset

Out of the 40 examined DAOs, 30 (75%) were active at the time of the study. We could collect size information of 30 DAOs (75%), which have, on average 14k members (i.e., users registered in the DAO) and a median of around 300 members. In the dataset, only two DAOs have over 100k members; with the largest having more than 250k members. About a quarter of the DAOs have less than 30 members.

After converting the community sizes to their corresponding categories (see Table I), we can see that almost half of the DAOs have a small number of members (i.e., up to 100 registered users), while more than 20% are of medium sizes (i.e., between 100 and 1k registered users). The remaining one-third of the DAOs are large (i.e., between 1001 and 10k registered users) and extra-large (i.e., more than 10k registered users). The small DAOs have, on average, 38.07 members (std = 31.52) and a median of 26 members. In general, the medium-sized DAOs have 509.28 members (std = 304.24) and a median of 422 members.

If we analyze the community size together with the "is-active" dimension, we uncovered that out of the 30 DAOs of which we have data about their community size, four of the 13 small DAOs (30%) were inactive at the time of the study. While all of the 17 medium-, large-, and extra-large-sized communities were found to be active.

We were able to gather treasury information for 21 DAOs, while treasury details for 19 DAOs were not available. The collected DAOs manage an average treasury of $45M, with a median value of nearly $2M. Nine of the 21 DAOs (22.5%) were categorized as having a small treasury of $20k on average (std = 19 783.36), while five DAOs (12.5%) were identified as managing a medium-size treasury of about $6M in average (std = 3 934 765.84). The largest treasury in the dataset corresponds to the DAO Decentraland, which manages a capital of $400M and operates in the entertainment (gaming) industry. We calculated Spearman's correlation coefficient to examine the relationship between the community size and treasury size of the DAOs. For the 21 DAOs, the correlation coefficient is 0.78. This indicates a strong positive relationship, suggesting that as the community size of a DAO increases, so does the amount of money managed by the organization. In other words, the size of the organization is directly associated with the extent of funds under its management. Three out of the nine DAOs (33%) with the smallest treasury showed to be inactive; the rest were all active at the moment of the study. Similar to the case of community size, the only inactive DAOs correspond to those with the smallest treasury.

Among the 40 DAOs analyzed, the majority operate in the domains of Technology (17 out of 40, 42.5%) and Finance (30%). Other domains such as Social (10%), Entertainment (7.5%), and Legal (5%) are less common. In terms of purpose, the majority of DAOs (29 out of 40, 72.5%) provide services, while 6 out of 40 (15%) focus on peer production and 4 out of 40 (10%) are oriented toward granting. Regarding the decision-making processes within these DAOs, we found that in all cases (100%), voting does not require participants to forfeit their deposited tokens. Additionally, in 30 DAOs (75%), participation is open to all members, and in 19 (47.5%), the weight of a vote is determined by the number of tokens owned by the voter. However, information about the specific participation mode, vote weight, and vote cost could not be found for six (15%), four (10%), and three (7.5%) DAOs, respectively.

We found that the 38 DAOs use in total 60 tokens in their internal operation. Tokens of the DAOs `Cyber Congress` and `LexDAO` lacked reliable information to be included. Most DAOs (22 out of 38, 58%) employ one token. Eleven DAOs (29%) use two tokens, four DAOs (11%) operate with three tokens, and the DAO `Decentraland` utilizes four tokens. No token is used by more than one DAO, indicating that each DAO has its unique set of tokens.

The majority of DAOs use tokens for governance (35 out of 40, 87.5%) and financial purposes (23 out of 40, 57.5%). Twenty-one out of the 40 DAOs (52.5%) employ tokens to reward their members, while 14 DAOs (35%) have tokens that allow members to access the services offered by the DAO. Only 5 out of 40 (12.5%) DAOs operate with reputational tokens and five use membership tokens.

In relation to the utility of the tokens, which is a non-exclusive dimension in our coding scheme, most of the tokens (46 of 60, 77%) are used for governance. Of the 46 governance tokens, 15 (33%) also have financial usage. Twelve tokens (26%) used for governance are likewise employed to reward members of the DAOs, while ten (22%) allow members to use or consume the services offered by the DAO. Nine tokens (15%) are used for financial purposes but not for governance.

Regarding the non-exclusive dimension of issuance, more than half of the 60 tokens (34 of 60, 57%) are issued in exchange for contributions to the DAO. However, 20 of these 34 tokens (59%) can also be purchased in the market. Out of the 34 contribution tokens, 11 (32%) can be obtained by acquired rights, like being the founder of the DAO.

About the supply, 45% of the tokens (27 of 60) have a fixed supply, which means that the total number of tokens that will ever circulate in the system is decided at creation time. Even if all tokens are not yet in circulation and they continue to be generated, there will come a time when the total supply will reach its upper limit and no additional tokens will be issued. In 23% of the cases, the total supply is conditioned by predetermined rules. These DAOs either have a fixed issuance scheduled with an infinite supply or follow a policy that makes predictable the token supply (e.g., the DAO `1hive` mints `HNY` when the common pool balance is less than 30% of the total supply). Besides, their supply may depend on the quantity of an established cryptocurrency with conditional supply, like `ETH`. In this case, tokens can only be issued if units of the established cryptocurrency are circulated. For nine tokens (15%), the total supply is adjustable, i.e., it does not depend on predefined conditions, but proposals to modify the supply of the token may be accepted during the lifetime of the DAO. We could not obtain supply information for ten tokens (17%).

Almost all tokens (55 out of 60, 92%) are fungible like cryptocurrencies, i.e., they are not unique, divisible, and

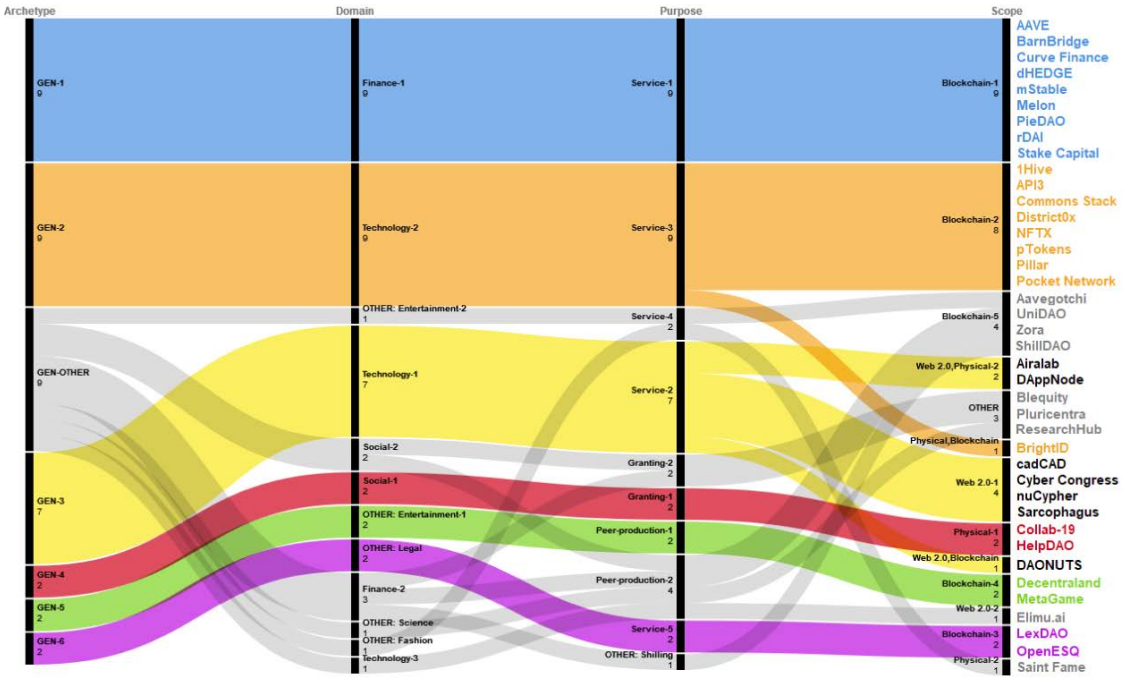

Fig. 1. Alluvial chart illustrating the emerging DAO archetypes for the general categories.

interchangeable. At the same time, the majority are transferable (72%) and have no monetary value, i.e., they do not appear in coinmarketcap.com (62%). A quarter of the tokens (16 of 60) are fungible, transferable, and do not have a monetary value.

B. Archetypes of DAOs

Based on the categorization done using our coding schemes (see Section IV), we focus on identifying archetypes for the DAOs. We use the descriptive construct of DAOs and tokens archetypes to categorize types of DAOs and tokens. An archetype is defined as a frequently observed tuple of values along the coding scheme dimensions.

1) General Scheme: All dimensions of the general scheme (see Table I) except "community size" and "treasury" were employed to characterize DAOs into archetypes. We decided to exclude these two because of missing 25% and almost 50% of the data, respectively. We obtained three archetypes (GEN-1, GEN-2, and GEN-3) that cluster the majority of the DAOs (63%), as shown in Fig. 1. The alluvial plot represents how the archetypes found in the general scheme (leftmost column) relate to the three dimensions of the scheme, i.e., domain, purpose, and scope, in the next columns. Each archetype is represented with a distinct color. The name of the DAOs in each archetype appears on the right margin.

As an example on how to read the figures, we can observe all the DAOs from the GEN-1 archetype (in blue in Fig. 1), belong to the Finance domain (second vertical bar), provide a service (third bar), with a scope solely on blockchain (fourth bar). However, the GEN-3 archetype DAOs (in yellow), are technological (second bar), and provide services (third bar) to three differentiated scopes (fourth bar): Web 2.0; both Web 2.0 and Blockchain; and Web 2.0 with physical elements.

GEN-1. DAOs offering services in the financial domain: One of the two most prevalent archetypes corresponds to DAOs that operate offering financial services on the blockchain. Nine out of the 40 DAOs (22.5%) are part of GEN-1, 90% of which were active at the study's moment. A representative example is `Curve Finance`, a decentralized exchange liquidity pool for trading stablecoins.

GEN-2. DAOs providing blockchain-based services: The other most frequent archetype relates to DAOs that operate in the technology domain offering services on the blockchain. Nine out of 40 analyzed DAOs (22.5%) fall under this archetype, all of which were active. An example is the DAO `BrightID` that provides a blockchain-based solution for digital identity verification.

GEN-3. DAOs providing web-based services: The third-largest archetype comprises DAOs that run on the technology domain, offering primarily web-based services. However, some also provide services on the blockchain and in the physical world. Seven DAOs (17.5%) are represented in this archetype; only one of them was found to be inactive. An illustrative example is `Airalab`, which provides an IoT platform for connecting robotics using smart contracts.

GEN-4. DAOs funding social projects in the physical world: Just two DAOs (5%) (see Fig. 1) support social projects in the physical world, and both were inactive at the time of the study.

GEN-5. DAOs offering entertainment products: This archetype includes two DAOs (5%) from the entertainment industry, offering blockchain-based virtual worlds and online games; both were active at the time of the study.

GEN-6. DAOs providing legal services related to blockchain: This archetype includes DAOs in the legal domain offering legal services related to the blockchain ecosystem (e.g., Metaverse). Two DAOs `LexDAO` and

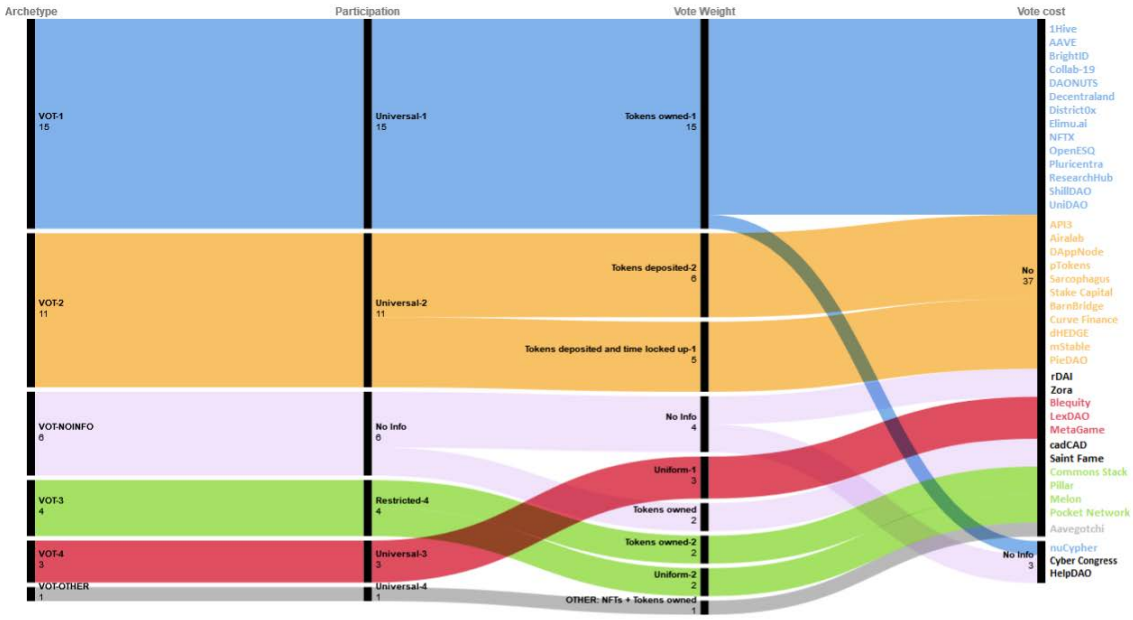

Fig. 2. Alluvial chart illustrating the emerging DAO archetypes for the voting categories.

`OpenESQ` (5%) are part of the archetype, but only one LexDAO was active.

GEN-OTHER: The remaining nine DAOs (22.5%) lack a cohesive entity according to the considered dimensions. Three are financial DAOs, two deal with social causes, another is in the technology domain, and the rest are in other fields, including science, entertainment, and fashion.

2) Voting Scheme: To identify archetypes in the voting mechanism of the DAOs, we considered all dimensions of the voting scheme (see Table II). Fig. 2 shows the resulting archetypes and reveals that a majority of the DAOs (65%) are concentrated within VOT-1 and VOT-2. In this section, we explain in detail the archetypes found in the figure.

VOT-NOINFO: This label groups the six DAOs (15%) of which we could not collect voting process information.

VOT-1. DAOs with universal participation depending on the tokens owned: A large group of DAOs (15 of 40, 37.5%) allows universal participation in the decisions, but the weight of the votes depends on the number of tokens owned by the voter. Most of the DAOs in this archetype are active (10 out of 15, 66%). `ResearchHub` is an example of DAO that makes decisions under these conditions.

VOT-2. DAOs with universal participation depending on the tokens deposited: The second largest archetype corresponds to DAOs that allow universal participation but where the voting power depends on the tokens deposited in the vote. Eleven of the 40 (27.5%) DAOs follow this approach when making decisions. In contrast to VOT-1, all DAOs in this archetype are active. A good example is the DAO `API3`, which provides decentralized APIs for web3 technology.

VOT-3. DAOs with restricted participation: Four DAOs (10%) belong to this archetype where vote participation is restricted to a particular group of members (e.g., founders or special committees). In half of the DAOs, the voting power depends on tokens owned by the voter, while in the other half, votes have the same weight. An example is `Commons Stack`, which offers technology services on the blockchain.

VOT-4. DAOs with universal participation and uniform voting power: Only three DAOs (7.5%) allow universal participation with equal voting power. Such DAOs might suffer a Sybil attack,[8] but usually filter the member admission or use mechanisms, such as BrightID, to verify the member identity. Two out of the three DAOs in this archetype are active: `LexDAO` and `MetaGame`.

VOT-OTHER: This group consists of a single DAO (see Fig. 2) that offers universal participation, like DAOs in VOT-1, VOT-2, and VOT-4. Still, its vote weight depends not only on the number of tokens (NFTs here) of the voter but also on the weight assigned by the DAO to each token.

C. Clusters of Tokens

After applying the K-means algorithm, we found four clusters. Their characteristics are presented in detail below.

TOK-1: One-third of the tokens (19 out of 60, 31.7%) are represented in this cluster. These tokens are primarily used for governance and issued by purchase with a fixed supply. They are fungible, transferable, and do not have monetary value in the market. The token `Elimu` of the DAO `Elimu.ai` is an example of tokens in this cluster.

TOK-2: This cluster includes 17 tokens (28.3%) that serve for governance and are issued by contributions. They have an adjustable supply and are fungible; however, they cannot be transferred and do not have monetary value in the market. The token `veDOUGH` employed by the DAO `PieDAOv` is an example of this type of token.

TOK-3: A quarter of the tokens (15 out of 60, 25%) are classified under this cluster. They are employed for financial,

[8]A Sybil attack occurs when the attacker simultaneously operates many active fake identities undermining the authority of a computer network service.

governance, and reward purposes and issued by acquired rights, contributions, and purchases. These tokens have fixed supply and value in the market, and are fungible and transferable. The token API3 created by the DAO API3, which operates on the Ethereum and is valued in 2$, represents an example of tokens in this cluster.

TOK-4: Nine out of the 60 analyzed tokens (15%) are grouped in this cluster. They correspond to tokens used for financial, reward, and usage purposes, which are issued by acquired rights, contributions, and purchases. They have a conditional supply, are fungible and transferable, and have monetary value in the market. The token HNY of the DAO 1Hive, valued at almost 40$, is a representative case of the tokens in this cluster.

D. Association Between Archetypes

The Fisher exact test with threshold $\alpha = 0.05$ shows that there is no association between the General and Voting schemes (p-value $= 0.078 > \alpha$), i.e., their archetypes do not co-occur more or less frequently than expected.

In contrast, the association was statistically significant for the general and token schemes (p-value $= 0.002 < \alpha$). The Pearson residuals show that the only significant co-occurrence happens between TOK-1 and the GEN-OTHER group of the general scheme. The association was also significant regarding the voting and token schemes (p-value $< 0.001 < \alpha$). In this case, the Pearson residuals reveal that the co-occurrence of VOT-1 and TOK-1 was larger than expected, while the pair VOT-1 and TOK-2, and the pair VOT-2 and TOK-1, were smaller than expected. It means that DAOs in VOT-1 (universal participation and weighted voting) seem to be strongly associated with governance tokens in TOK-1 (purchasable but with no monetary value). In contrast, DAOs in VOT-1 are not associated with governance tokens in TOK-2 (issued by contributions and with no monetary value). Similarly, we observed an inverse association between VOT-2 and TOK-1, indicating that DAOs with universal participation based on token deposits tend to not utilize governance tokens that can be purchased. Still, we observe a weak link between the governance structure and the acquisition of governance tokens.

Despite identifying recurring patterns within each coding scheme, the significant associations found are limited and weak. This finding highlights the overall diversity of Aragon DAOs. The weak associations suggest that there is no dominant pattern or strict adherence to specific governance structures or token mechanisms among the DAOs analyzed.

VI. Discussion

A. DAOs Offer Financial and Technological Services

Although blockchain enthusiasts claim DAOs may be applied to multiple sectors like healthcare, retail or supply chains [55], our research shows that nowadays DAOs are primarily used to provide blockchain-based services in the financial and technological domains. On the one hand, DAOs with a financial purpose and that offer services on the blockchain (e.g., Aave, BarnBridge, Curve Finance) aim to construct flourishing ecosystems of decentralized economies. For example, Aave is a decentralized liquidity market protocol where users can lend or borrow cryptocurrencies, earning or paying interest in return. On the other hand, DAOs that operate in the technology domain provide software solutions on the blockchain (e.g., decentralized applications, protocols, and APIs) and web-based services. For example, the DAO BrightID works on a platform to secure digital identity and personal control over people's authentication. In this way, BrightID allows people to prove to software applications that they are not using multiple accounts. For its part, DAppNode allows users to deploy and host decentralized applications, P2P clients, and blockchain nodes, providing access to them through a decentralized protocol. Since DAOs run using blockchain-based software, it is not surprising that most are strongly related to managing blockchain technology or crypto-finance projects. Note the majority of these DAOs were active at the moment of the study.

In contrast, we see DAOs related to the offline world are rare. Particularly, those supporting social causes seemingly strive to survive. For instance, Collab-19 and HelpDAO were created during the Covid-19 pandemic to raise funds and mobilize volunteer teams for local crisis response. However, their limited longevity could be attributed to their time-sensitive nature, or the difficulties associated with employing DAOs for real-world projects. Donors may be unsure of how cryptocurrency funds can be effectively utilized to support causes, potentially deterring participation. Moreover, the unfamiliarity of potential donors with blockchain technology and the preference for traditional online payment systems during times of crisis may further hinder the success of these DAOs. In fact, research has shown the challenges faced by new users in adopting blockchain technology [28], [56].

DAOs operating in the entertainment sector, such as Decentraland and MetaGame, have experienced success, benefiting from the rapid growth of the gaming industry. These DAOs support blockchain-based virtual worlds that enable users to create, explore, and monetize content. The integration of digital games with the blockchain ecosystem contributes to the thriving nature of these DAOs [57]. However, the application of DAOs in the legal services domain has yielded mixed results. While LexDAO continues to provide legal consulting on smart contracts, OpenESQ, a DAO offering legal advice for crypto-assets and smart contracts, has been abandoned. It may be premature for the DAO ecosystem to tackle legal challenges or offer legal services due to the current usability issues [56].

B. DAOs are Governed by Universal Participation

We found that voting practices in DAOs are pretty much standardized. Most allow universal participation of their members. However, the vote weight typically depends on the number of tokens owned or deposited by the voter (31 out of 40 DAOs), while uniform voting power is observed only in five DAOs. Moreover, we found that DAOs in which the vote weight depends on the tokens owned, tend to use governance tokens that can be purchased. This results in market-driven governance systems [2]. As a result, plutocratic regimes that

concentrate power on a few individuals or groups might emerge [29], [58]. A 10% of the DAOs restrict the governance to selective groups of members, like founders. In all cases, we observed that the act of voting does not directly affect voters, since they do not lose their tokens when making decisions.

C. DAOs Use Fungible and Transferable Governance Tokens

DAOs operate, typically, with a single token. Others, such as `AAVE` or `BrightID`, employ more than one token, each serving separate purposes. In DAOs, tokens are primarily used for governance or financial purposes and can be acquired by rights (e.g., being a founder of the DAO), contributions to the DAO, or purchasing them. We observed that tokens have, in general, a fixed supply, which means that their total supply is predefined at creation time. Most of them are transferable and fungible. Along this line, previous research has discussed the fundamental role of financial, transferable, and fungible tokens with fixed supply in the rise and consolidation of DAOs [59].

D. Limitations

The findings presented in this article are tightly connected to the Aragon platform and should be interpreted within that context. The curation process of DAOs on Aragon's website introduces potential biases, and the limited and volatile information about DAOs posed challenges in gathering the data. In some cases, like the dimensions "community size" and "treasury," the information was scarce, hindering the potential conclusions. The descriptive nature of the study and the small sample size (when compared to large quantitative research), limit the ability to draw causal conclusions and generalize the findings. However, the research was rigorous and substantial, providing valuable datasets and insights for further investigation. The authors hope that this work will inspire future research in this emerging field.

VII. Conclusion

This pioneering study applies a rigorous methodology to qualitatively characterize a substantial sample of DAOs. This research introduces a categorization scheme that comprehensively describes DAOs, encompassing their voting systems and token usage. By analyzing a sample of 40 DAOs and 400 000 users on the Aragon platform, the study identifies prominent patterns and trends using empirical analysis and statistical methods. Overall, this research sheds light on the emergence of various types of online communities within the realm of the so-called "digital jurisdictions."

Our findings reveal aspects of DAOs that have not been studied systematically to date. We examine the nature of DAOs, how they are used, and the extent to which they fulfill their intended purpose of democratic governance. Our findings indicate that, despite being intended as general-purpose tools, Aragon DAOs are primarily focused on the financial and technological domains, providing blockchain-based services. This tendency may stem from the fact that blockchain technology is predominantly associated with financial operations [60], while also reflecting the challenges that hinder mass adoption of blockchain technology among novice users [27], [28], [60].

In terms of governance, the Aragon framework offers flexibility, allowing for various voting systems. Our study identifies some major trends in this regard. First, universal participation and cost-less decision-making is commonly observed, indicating a democratic approach to access. However, the influence of voters tends to be proportional to the number of tokens they own, highlighting a token-weighted power distribution. Besides, most governance tokens used are fungible and transferable, meaning they can be obtained through purchase or as reward for contributions. This raises the possibility of meritocratic or wealth-based governance models, resembling plutocratic systems rather than the traditional one-person-one-vote democratic ideal [2], [29], [58].

Overall, our research provides valuable insights for researchers and practitioners in understanding the prevailing trends in DAOs, including project types, decision-making processes, and token usage. These findings can assist the academic community in designing and implementing their DAO initiatives on the Aragon platform more effectively. Additionally, the methodology we employed can serve as a useful framework for future studies, allowing for the application of categorization schemes to analyze DAOs in different time periods or on alternative platforms, thereby enabling comparisons and contrasting of results.

Concerning future work, there are multiple ways this study can be expanded. Focusing on decision-making processes, future studies could analyze factors such as quorum requirements, support levels, and differential voting. Other possibilities involve analyzing voting performance by examining actual votes carried out by DAOs, exploring participation levels, occurrence of disputes, and the impact of voting systems. Following on this research line, new metrics could facilitate studies in terms of equity and representation.

The archetypes could be validated through expanding this research to other DAO platforms different than Aragon. Thus, we could explore the similarities, differences, and evolution of the use of DAOs across platforms. In addition, the whole scheme could be expanded with other dimensions, such as security issues or scalability. Expansions of the scheme could enable the exploration of patterns across successful DAOs or inactive DAOs, to identify common factors and provide guidance to practitioners.

Finally, this approach could be complemented with qualitative research, conducting interviews with DAO members to gain insights into their motivations, satisfaction, and challenges. Such a comprehensive approach will enhance our understanding of DAO dynamics and provide valuable insights for improving DAO initiatives.

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