A Taxonomy of Decentralized Autonomous Organizations

Completed Research Paper

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Abstract

Decentralized Autonomous Organizations (DAOs) are trustless organizations that automate transactions, operations, and decisions without a trusted third party (Wang et al. 2019). So far, this research area is missing a taxonomy that investigates the different dimensions and characteristics of DAOs and the many different forms they can take. This paper addresses this research gap by creating a data-driven taxonomy analyzing 72 DAOs. In doing so, we identify the three main categories treasury, community, and governance, seven sub-categories, 20 dimensions, and 53 characteristics. In addition, we provide dimensions with inadmissible characteristics DAOs cannot take, as well as dimensions used to assess DAOs. The results of our agglomerative clustering are five distinct DAO types: On-chain product and service DAOs, off-chain product and service DAOs with community focus or with investor focus, investment-focused DAOs, and networking-focused community DAOs.

Keywords: Decentralized Autonomous Organizations; Taxonomy; Blockchain

Introduction

Decentralized autonomous organizations (DAOs) are an increasingly important topic in information systems, organizational sciences, and practice. The total market capitalization of the top ten DAOs now exceeds 8 billion dollars, with BitDAO alone having a market capitalization of 2.2 billion dollars (DeepDAO 2022). The increase in market capitalization was mainly fueled by the interest of institutional investors, who have been starting to invest in DAOs lately. The famous venture capital firm, Andressen Horrowitz (a16z), has invested in DAOs, such as Syndicate (Yahya 2021b), Friends With Benefits (Carra Wu and Chris Dixon 2021), BreederDAO (BreederDAO 2022), and PleasrDAO (Yahya 2021a).

Due to the growing interest in information systems, scholars have recently called for the classification of perceived DAOs particularly those closely related to Decentral Organizations (Dos) (Rikken et al. 2021); for which our taxonomy lays the foundation. Previous research has predominantly studied DAOs from a descriptive, theoretical perspective; or else it has analyzed a small number of DAOs or specific events, like the DAO hack (Dhillon et al. 2017) and governance at a general level (Rikken et al. 2021). Research so far leaves behind a need for research into various types of DAOs and for clarification of relevant definitions and characteristics (Rikken et al. 2021).

Wright (2021) has offered an intuitive taxonomy for DAOs, which describes two distinct organizational designs: Algorithmic DAOs and Participatory DAOs. While we agree with the intuitive taxonomy of Wright (2021), a more sophisticated, comprehensive, data-driven taxonomy that looks at the specific characteristics of DAOs offers advantages for further research into DAOs. A more comprehensive taxonomy is necessary, as only a data-driven taxonomy that looks at these characteristics allows researchers to build solid models. These models are used to predict the performance of DAOs or to provide information about

the trustworthiness of DAOs in terms of real-world DAO development. A data-driven type of taxonomy is more reliable, precise and applies to more DAOs. Thus, it is more conducive to the systematization of future DAO research.

Therefore, we formulate our primary research question as follows:

RQ: Which common characteristics do DAOs share, and which clusters of DAOs can be created, based on their characteristics?

Following Rikken et al. (2021), we define DAOs as "a system in which storage and transaction of value and notary (voting) functions can be designed, organized, recorded, and archived; and where data and actions are recorded and autonomously executed in a decentralized way". Furthermore, we extend the definition by requiring an explicit notary (voting) process for each DAO. An explicit notary (voting) requires a process that is not ad hoc and leaves space and time for discussion. In contrast, an implicit voting process allows eligible voters to vote without any process and discussion. Additionally, we impose a limitation on our DAO dataset insofar as a DAO cannot be a group of people with access to a multi-signature wallet without any other tools; where this wallet holds funds without the existence of any formal voting procedure. Lastly, we require a DAO to have an ecosystem where contributors are rewarded for their work. We implement these three limitations as we focus on organizations that are mature and not in a transition or setup phase where certain procedures are not fully implemented yet.

In the next section, we briefly explore the foundations and present work related to our research. Next, we present our methodology by introducing meta-characteristic and ending conditions and simultaneously describe our methods for data collection, iterations, and evaluation. We then present the resulting taxonomy and explain all of the relevant dimensions in detail. After that, we apply our taxonomy, using clustering techniques to identify categories of DAOs. Finally, we discuss the direct result of this work and explore future research opportunities.

Foundations and Related Work

In this section, we explain first the core concept of DAOs. We present two different definitions of DAOs and refine our definition for this work, based on an existing definition for DAOs. Then we explain the need for taxonomies and how researchers can use them in closely related fields. Last, we state the main reason for this research and the research gap.

The core concept of DAOs is that a virtual entity with a particular set of members, who are shareholders, that have the right to vote, spend the entity's funds, and modify its code. This concept allows members to decide the organization's future and its assets collectively, using smart contracts (Buterin 2013). Furthermore, there have been other definitions of DAOs. For example, Hsieh et al. (2018) define DAOs "as non-hierarchical organizations that perform and record routine tasks on a peer-to-peer, cryptographically secure, public network, and rely on the voluntary contributions of their internal stakeholders to operate, manage, and evolve the organization through a democratic consultation process." However, with this definition, blockchain-based systems like Bitcoin are categorized as DAOs (Buterin 2014; Hsieh et al. 2018). Also, Rikken et al. (2021) maps a wide range of DAO definitions and characteristics, in order to derive a comprehensive definition therefrom.

In recent years, multiple scholars have researched DAOs, which has led to a fragmented understanding of DAOs. For example, Wang et al. (2019) brings up a reference model for DAOs. Hsieh et al. (2018) states the history of DAOs and developments starting with Bitcoin. Hassan and Filippi (2021) discuss the origin and evolution of the term *DAO*, as well as relevant definitions and open questions; while El Faqir et al. (2020) showcase DAO tools.

There have been various studies of taxonomies in closely related fields, such as blockchain-based-systems (Glaser 2017; Glaser and Bezzenberger 2015); smart contracts (Hofmann et al. 2021); ICOs – a blockchain-enabled form of crowdfunding (Fridgen et al. 2018); and crowdfunding (Haas et al. 2014). Still, to the best of our knowledge, nobody has ever offered a systematic taxonomy of DAOs; identifying the full spectrum of their organizational primary and secondary functional building blocks, such as governance and reward mechanisms. This research is highly required because further studies on DAOs need a profound taxonomy as a foundation. For example, there have – so far – not been any quantitative studies looking at how these organization and governance structures relate to DAO performance both during, and after, the launch of a

DAO. However, Zhao et al. 2022 look at how strategic and operational voting tasks influence product quality. They conclude that the number of operational voting tasks negatively affects product quality. Furthermore, they conclude that strategic voting tasks influence product quality when taken as a proportion of the total workload and not analyzed directly.

Tsoukalas and Falk 2020 investigate the effectiveness of decentralized platforms witch use token-weighted-voting and crowdsource information from users. They find that token-weighting generally discourages truthful voting. Additionally, they find that „Platform accuracy decreases with the number of truthful users and the dispersion in their token holdings".

While these studies have enhanced our understanding of certain DAO dimensions, they so far have not looked at most dimensions of a DAO but merely at a smaller set of dimensions such as voting in a DAO.

A solid taxonomy, containing a synthesis of current knowledge regarding organizational design, governance, reward mechanisms, and launch paths, is needed to foster a shared understanding for future research. Our taxonomy builds on Rikken et al. (2021), who provide an in-depth study of DAOs by analyzing definitions, characteristics, and emerging developments.

Methodology

We follow an iterative, two-step approach that combines empirical, conceptual, and deductive research methods; this, in turn, develops a taxonomy that can be used to answer the research question and to lay a data-driven foundation for future research on DAOs. We use the seven-step iterative model by Nickerson et al. (2013) and extended this model with an eighth step; namely, a qualitative evaluation using semi-structured expert interviews, following the approach described by Finkbeiner (2017). Taxonomies offer a list of dimensions that each have a set of characteristics. However, only one character can be assigned to each dimension for a single object of study Nickerson et al. (2013). We chose this approach, because it is field-tested in the area of information systems, including in the field of blockchain-based technology (Fridgen et al. 2018; Hofmann et al. 2021). We depict the complete approach in Figure 1.

Haas et al. (1966) list the possible uses of taxonomies with an empirical basis: they may be (1) strategically helpful for refining hypotheses; (2) aid in the investigation of validity and utility of intuitively based typologies; (3) serve as a basis for predicting organizational decisions or change. We use argument (2) to challenge the proposed, intuitive taxonomy of Wright (2021).

While there has not been any focus on taxonomies in DAOs, the general research on taxonomies for scientific purposes, especially in organizations, is vital for fundamental steps in a field; because it provides the elementals for developing and testing hypotheses (Rich 1992). It also provides the basis for midrange theorizing about the factors that impact different types of organizations, without resorting to general style theories applicable to all types of organizations (Rich 1992).

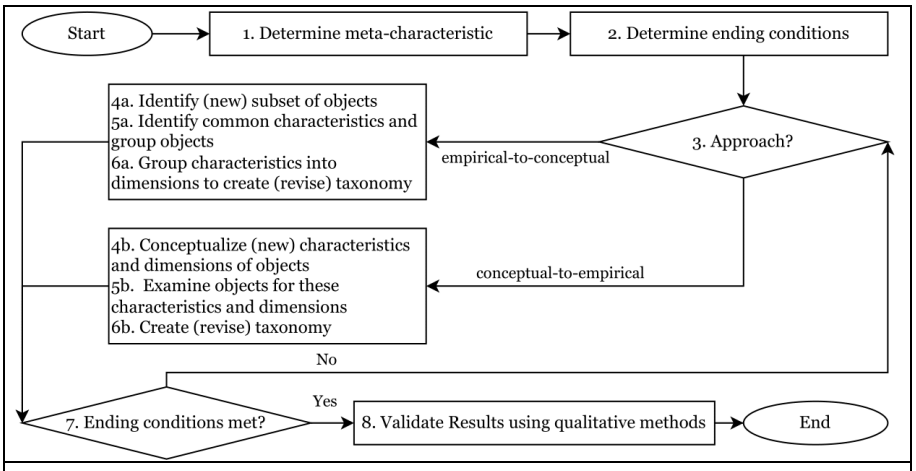

Figure 1. Our Extended Research Model of Nickerson et al. (2013)

As mentioned above, Figure 1 shows our research approach, which we now explain further.

(1) The first step of the research method used is to define a meta-characteristic. "The meta-characteristic is the most comprehensive characteristic that will serve as the basis for the choice of characteristics in the taxonomy" (Nickerson et al. 2013). The meta-characteristic should be based on the purpose of the taxonomy and the purpose of the taxonomy should be based on the expected use of the taxonomy.

(2) Ending conditions are used to decide when to terminate the iterative approach. This approach only ends once all ending conditions are satisfied. To satisfy the constraints of this approach, the resulting taxonomy has to meet at least the fundamental objective ending conditions set by Nickerson et al. (2013). Additional criteria can be added, as needed.

While we use, primarily, the framework of Nickerson et al. (2013) to develop our taxonomy, we also take note of Rich (1992). He collected various pieces of advice on taxonomy development, especially dimension filtering, with the main point being to prioritize dimension quality over quantity (Mayr 1969). Furthermore, he summarizes the criteria used to define inadmissible dimensions, as listed during the application of this methodology. We use these, in addition to the subjective and objective ending criteria defined by Nickerson et al. (2013). The specific ending conditions are described in the chapter on the application of the methodology.

(4a) For the empirical-to-conceptual approach, the researcher first identifies a subset of objects that should be classified. The possible object selected can be either one that the researcher is most familiar with, any of the ones most easily accessible, or objects gathered from a review of the literature. If the number of objects selected is too great, a subset can be selected. This subset can either be random, systematic, convenient, or some other type of sample.

(5a) From this subset, the researcher identifies the most common characteristics of these objects; while the characteristics must be a logical consequence of the meta-characteristic. During this process, non-relevant characteristics may be identified and later eliminated to fit the ending conditions.

(6a) Once a set of characteristics has been identified, those characteristics can be grouped formally by the researcher, using statistical or informal techniques involving manual or graphical processes.

(7) After each iteration, the ending conditions are checked, provided all of them are satisfied. The first iteration is very unlikely to yield a satisfactory result. Therefore, a new iteration is started, where the researcher can again choose between the empirical-to-conceptual and the conceptual-to-empirical approaches. After each iteration of the design process, new dimensions may be added and existing ones eliminated.

In the conceptual-to-empirical approach, the researcher first conceptualizes characteristics and dimensions, examines objects connected with those characteristics; and then creates or updates the taxonomy. In this work, we perform two different conceptual approaches, one as described by Nickerson et al. (2013), where the researcher conceptualizes new objects on their own; and one conceptual approach, where we conceptualize new characteristics through a design space approach (Biskjaer et al. 2014). In this, we crowdsource new characteristics through collaborative brainstorming, which we then, in turn, implement into our taxonomy. In the design space, each problem defines a set of constraints that lead to possible worlds that satisfy the constraints specified. In this paper, we propose constraints for a virtual collaboration area with constraints on the receipt of new characteristics from participants. Because brainstorming in groups is inefficient (Kohn and Smith 2011), we prepare the design space and let the participants contribute individually, on an iterative basis. Therefore, we define our design space Constraint as follows:

Initial content on the digital board: Stickers with initial instructions, one example dimension with two example characteristics, and empty stickers for new answers

Initial instructions: As a member of a DAO, you might know other DAOs. Think of two DAOs that you know. What differentiates the two DAOs you have in mind from each other? Please put the dimension in which they differentiate on a sticker and mark the characteristic on it

Location: Desktop, smartphone, tablet, laptop

Tangible shapes: Circle stickers, square stickers, text fields, lines, arrows

Basic idea: Create new stickers with DAO attributes and connect them

Use situation: Individual

Interaction: Editing of stickers, coloring of stickers, deleting stickers, creating stickers, creating connections, deleting connection, ordering stickers

Purpose: crowdsource new DAO characteristics

Target audience: DAO members and web3 builders

Nickerson et al. (2013) states that upon completion of the complete taxonomy for DAOs, the result must be evaluated for its usefulness. We do this evaluation in two ways. First, we use the qualitative method of interviews, ask specific questions about usefulness; and then, we systematically analyze the interviews using Finkbeiner (2017), since we are interviewing high-ranking persons. Second, we cluster our results to identify patterns with which DAOs can be classified and then use them as a starting point for further evaluations. This, in turn, would help us to understand better what characteristics make DAOs successful.

Application of the Methodology

The application of our methodology is divided into the steps we have presented in Figure 1. We start with the definition of meta-characteristics and ending conditions.

Meta-characteristics and Ending Conditions

According to Nickerson et al. (2013) and the guidelines on choosing meta-characteristics, as described in the methodology, we chose *Attributes used to distinguish different types of Decentralized Autonomous Organizations* as the meta-characteristic for our taxonomy.

After each iteration, we analyzed our taxonomy regarding the ending conditions. We always started a new iteration whenever a single ending condition was not complied with. This cycle was performed until all ending conditions were met.

As described in our methodology, we use the ending conditions from Nickerson et al. (2013), as well as the inadmissible dimension constraints from Rich (1992). We start by checking the constraints from Rich (1992):

Meaningless dimensions that do not reflect the inherent qualities of the phenomena under study; (2) Logically correlated characters that prove to be the consequence of other characters; (3) Partially correlated characters where the dependence of one character on another is partial; (4) that do not vary across the sample; (5) Empirical correlations where one character can be highly related to another through empirical evidence.

We found out that none of the constraints applies to our taxonomy. Thus, we continually check the objective conditions from Nickerson et al. (2013):

All objects or a representative sample of objects have been examined. (2) No object was merged with a similar object or split into multiple objects in the last iteration. (3) At least one object is classified under every characteristic of every dimension. (4) No amendments to dimensions or characteristics were carried out in the last iteration. (5) No dimensions or characteristics were merged or split in the last iteration. (6) Every dimension is unique and not repeated. (7) Every characteristic is unique within its own dimension. (8) Each cell (a combination of characteristics) is unique and is not repeated.

After evaluating our taxonomy regarding objective conditions, we study the subjective ending conditions from Nickerson et al. (2013). These conditions require the taxonomy to be *concise,* as a lack of parsimony is a weakness; and comprehensive taxonomies could be challenging to understand for a researcher. Furthermore, it should be *robust* as a way of differentiating between the objects studied. Additionally, it must be *comprehensive;* meaning, it must be able to classify all known objects and all dimensions of objects of interest. Second, the taxonomy must be *extendible* and allow for the addition of further dimensions and new characteristics when new types of objects appear. Lastly, it must be self-*explanatory*.

Data Collection and iterations

We took the empirical-to-conceptual approach, starting with 4a) using a systematic sample of 35 real-world DAOs. We collected this list using (daolist 2022), a website that lists known DAOs and separates them into the categories Protocol, Service, Media, Social, Investment, Platform, and Collector. While this categorization has not been scientifically tested yet, nor is it commonly used, we decided that we would randomly sample five DAOs of each category for each iteration. We argue that the intuitive selection made by the website creators ensures a high enough degree of heterogeneity for our results to include nearly all the different dimensions for the taxonomy from this iteration alone. To gather more details about each DAO, we scraped the data from (DeepDAO 2022) by performing a snapshot of their database, using the unofficial REST-API Endpoint. This dataset primarily contains numbers about the treasury, token holders, active members, proposals, and votes.

Next, we reviewed every project website to find out as much as possible about every DAO. We performed seven iterations with each 5 DAOs, using this dataset. However, we removed 12 "DAOs" from this dataset, because they did not fit the definition of a DAO; or else because the marketing material found on their websites did not match the smart contracts and their interactions. In fact, for example, we removed the following organizations from our dataset: Yield Guild Games, UniWhales, rekt, Global Coin Research, DaoStack, PleasrDAO, HERSTORY, and Decentraland. After this, we took a non-overlapping random sample of seven DAOs, in order to perform the eighth iteration, thereby bringing our total dataset to 30 DAOs and the number of organizations examined to 42. After this, we took the Conceptual-to-Empirical approach; starting with 4b), where we added new dimensions and found them fitting for the DAOs. In total, we added five dimensions, using this approach in one iteration.

Next, we applied our design space approach. To fit our design space constraints, we used the software Miro, an online whiteboard for teams to ideate and brainstorm together. We created a new whiteboard and set up the initial content and the initial instructions. The software resolves the constraints of *tangible shape and interaction*. To fit the remaining constraints, *target audience, use situation,* and location, we invited fitting participants mostly through Discord community communication channels of DAOs, Twitter, and some peers. We used the resulting whiteboard-filled dimensions and characteristics for a conceptual-to-empirical iteration. We received over 500 views of different participants on our whiteboard and offered an incentive for every dimension presented on the board. However, only two dimensions were valid on none made it into our final taxonomy. We suspect that providing dimensions and characteristics is too complicated for the average DAO member.

Following, we perform a conceptual-to-empirical iteration using the characteristics identified by Rikken et al. (2021). Then we iterated over our list of DAOs, examined the DAOs for the given characteristics, and then updated the Taxonomy. After this, we used a stratified random sample from Messari 2022 by using the different types of DAOs available as filters such as collector, grants, impact, investment, media, product, etc. We have checked each listed organization to fit into the definition of a DAO for this work and added in total 42 more DAOs to our dataset totaling 72 DAOs, also adding Decentraland to the dataset again, as it now matches our definition.

For the creation and update of our taxonomy, we followed the guidelines of Rich (1992), respecting the specific guidelines for Breadth, Meaning, Depth, Theory, Quantitative Measurement, completeness, and recognizability.

Evaluation

After collecting 30 data points, we conducted seven semi-structured expert interviews for the evaluation, which lasted between 20 and 30 minutes. The interviews were performed and analyzed as described by Finkbeiner (2017). The interviews provided valuable real-world insights into DAOs and allowed us to perform conceptual-to-empirical rounds, adding two new dimensions to the taxonomy. Additionally, we have performed a second round of expert interviews with six experts and asked them about all objective ending conditions and confirmed that there were no duplicate dimensions or categories, no dimensions or categories that are a combination of one or the other, and that there are no meaningless dimensions or categories. Additionally, we have asked the experts about the preciseness, completeness of attributes, extensibility, and clarity of the taxonomy on a scale from one to ten. The average score for preciseness in our interviews was 8.5, completeness of attributes 8, extensibility 7.3, and clarity 7.1.

Taxonomy of Decentralized Autonomous Organizations

We present the final taxonomy in Table 1. It consists of three main categories, seven sub-categories, 20 dimensions, and 53 characteristics that we have defined according to the previously explained research method used to describe DAOs. We grouped the dimensions into sub-categories that we then grouped into main categories. Examples of dimensions are Community Membership Access, and Governance Voting is fully On-Chain.

		Dimension	Characteristics				
Community	**Membership**	Access	Open (56)	Token Ownership (12)	Token Staked (1)	Invitation (3)	
		Type	Profit from Tokens (43)	Community (17)	Decider (12)		
		Is hierarchical	Yes (8)	No (64)			
		Anonymity	Anonymous (16)	Pseudonymous (53)	Known (3)		
	Meta	Contributor Rewards	REP Token (5)	Governance Token (42)	Other Token (25)		
		Purpose	Community Building and Engagement (13)	Product Building and Management (48)	Investing or Fund Raising (11)		
Governance	**Token**	Type	Singular (65)	Primary and Reputation (7)			
		Supply Cap	Capped (61)	Uncapped (11)			
	Process	Entry Barriers	Ownership (58)	Ownership + Application (5)	Invitation (2)	Staking (6)	Election (1)
		is fully Public	Yes (66)	No (6)			
		Execution	Automatic (20)	Manual (52)			
		has Proposal Creation Restricted	None (13)	# Tokens Owned (37)	Allowlist (22)		
	Voting	is fully On-Chain	Yes (18)	No (54)			
		Power	# Tokens Owned (60)	Per Individual (5)	# Tokens Staked (7)		
		Limits	None (66)	Per Address (6)			
Treasury	**Meta**	Diversification	None (37)	Some (7)	Very (28)		
		Stakes Tokens	Yes (34)	No (38)			
		Capital Gain	Token Sales (10)	Services (47)	Investment Returns (15)		
	Setup	Initial Airdrop	Yes (32)	No (40)			
		Initial Token Sale	Yes (43)	No (29)			

Table 1. A Taxonomy of DAOs

In addition to our taxonomy and its dimensions and characteristics, we also highlight those dimensions removed in our iterations, in order to compile this taxonomy; the reason being that they do not fit taxonomies. But they do offer insight on inadmissible characteristics for DAOs, which some self-proclaimed DAOs have but which are not compliant with our definition of DAO. Table 2 highlights the inadmissible characteristics in italic. Once a DAO has this characteristic for the dimension concerned, we no longer consider it to be a DAO.

Dimension	Characteristics
Treasury Type	Smart Contract – *Single Owner – None*
Treasury is Public	Yes – *No*
Has Governance Voting Process	Yes – *No*
Has Governance Token	Yes – *No*

Table 2. Inadmissible Characteristics of DAOs

In addition to inadmissible characteristics, we have found other characteristics that can be used to assess DAOs but do not offer any benefit to our taxonomy. For Token Holders, Community Participation, and Treasury Size, we provide a segmentation into different sizes that we deem to be important for an assessment of DAOs in Table 3. We created the segments by looking at the raw values from our complete dataset and clustered them into groups that had the least inner distance within the clusters.

Dimension	Characteristics
Token Holders	Very Small – Small – Medium – Large – Very Large
Community Participation	None – Some – High – Very High – Full
Treasury Size	None – Very Small – Small – Medium – Large – Very Large – Main
Governance Process Portal	Standard-Software – Custom – None
Has Legal Entity	Yes – No
Underlying Blockchain	Ethereum – Other – Multiple

Table 3. Assessment Characteristics of DAOs

We now elaborate on each main category, sub-category, dimension, and characteristics. We also explain our additional assessment characteristics of DAOs.

Community

Communities are an essential part of every DAO. We have found several options on how membership in DAOs work and what parameters a community may have. Here, we describe these options and parameters.

Community Membership Access: Regarding access to memberships within a community, we have found out that a community can either be *Open, Token Ownership, Token Staked, or Invitation*. *Open* means that anyone can join the community, regardless of affiliation or ownership. The access type *Token Ownership* means that the DAO aspirant has to own a predetermined number of tokens in order to join a community. *Token Staked* means that a DAOs aspirant has to stake (lock) tokens for a set period, in order to join a community. *Invitation* refers to very limited access only granted when the DAO aspirant is part of the Multi-Signature wallet of the DAO. In most cases, the signature owners are decided at the founding of a DAO and are changed very rarely afterwards.

Community Membership Type: The type of membership refers to the purpose of the membership, which can be *Profit from Tokens, Community, or Decider/MultiSig*. *Profit from Tokens* describes a membership, where a member buys DAOs tokens with the sole expectation of monetary gain. *Community* represents a membership, where the main value-added for the user is access to the community and its knowledge. *Decider/MultiSig* refers to a membership type, where the primary purpose is to decide on proposals brought up in the DAO.

Community Membership is hierarchical: A Community can have single or multiple levels or tiers. For example, members can be dolphins or whales, where a dolphin has very few tokens of a DAO, while a whale owns a vast number of tokens; and both are given different ranks with different permissions within a DAO. Since there are various possibilities of levels, we only differentiate between *Yes* – has levels and *No* – does not have a hierarchy.

Community Membership Anonymity: We found out that Communities can have various anonymity levels, such as *Anonymous, Pseudonymous,* and *Known*. *Anonymous* means that the members are only known by their wallet address and cannot be linked to pseudonyms or real identities. *Pseudonymous* describes a Community, where members have nicknames, such as "Satoshi Nakamoto"; these are not their real names but are used consistently by users. *Known* characterizes a membership, where all members are known by their real name.

Community Meta Information – Contributor Rewards: Each DAO needs members or contractors working for it to evolve. There are different options for rewarding contributors, such as *REP Tokens, Governance Tokens,* or *Other Tokens*. Reputation Tokens (*REP Tokens, for short)* are non-transferable tokens that can be used mostly for voting in DAOs. *Governance Tokens* are the same, but they are transferable. *Other Tokens,* such as Ethereum, Bitcoin, or USDC, may also be used to reward contributors.

Community Meta Information – Purpose: The dimension *Purpose* tries to describe roughly what a DAO's main goal is. We have found that there are three groups: *Community Building and Engagement*, *Product Building and Management,* and *Investing or Fund Raising*. *Community Building and Engagement* is about creating awareness for anything exploiting the concept of a DAO. *Product Building and Management* can be a service for DAO tooling, a service for creating DAOs themselves, hosting infrastructure as a server, etc. The main goal of *Investing or Fund Raising* is to find either profitable ventures to invest in as a group or to raise funds for what may sometimes be charitable purposes.

Governance

The Governance of a DAO describes how a DAO manages itself, allocates funds, and decides in which general direction to move. It is the core of every DAO, and lots of different methods for handling governance in a DAO are available. Here, we provide a list of dimensions, by means of which DAO Governance can be best categorized.

Governance Token Type: *Token Type* specifies the underlying options of the governance token—our taxonomy states the options *Singular* and, *Primary and Reputation*, where *Singular* is a single token type such as ERC20, ERC721, etc. *Primary and Reputation* can be a single token of any kind with the addition of a reputation token which the DAO hands out for contribution.

Governance Token Supply Cap: *Token Supply* can either be *Capped* or *Uncapped,* where *Capped* describes an unchangeable maximum supply set in a smart contract. *Uncapped* allows for further minting of governance tokens. For no governance token, we default to *Capped* for having a fixed number of zero tokens.

Governance Process Entry Barriers: We make a general distinction between access to the community of a DAO and access to the governance of a DAO. The entry to governance is always gated through one of the following: *Token Ownership, Invitation, Token Ownership and Application, or Token Staking*. *Token Ownership* means that members have to own a token to vote. *Invitation* means that members have to receive an invitation from the DAO before taking part in governance. *Token Staking* refers to members needing to stake tokens before being admitted to the governance process. *Token Ownership and Application* relates to members having to apply to the DAO and holding a token to vote.

Governance Application is fully Public: Here, we refer to the accessibility of the governance process. If the entire process is visible outside without any barriers, we use the characteristic *Yes*. Otherwise, *No*.

Governance Process Execution: Once a proposal has passed, the result of the proposal has to be executed. For example, if a proposal is passed to allocate X number of tokens to Y, this transaction must be executed. It can either be executed *Automatically,* for example, using connected Smart Contracts, or *Manually,* where one or more members of the DAO must issue the transaction in good faith.

Governance Process has Proposal Creation Restricted: Proposals build the core of every governance system in a DAO. DAOs can restrict who can create a proposal. This restriction is, for example, useful in very large DAOs to prevent spam and keep focus. The possible characteristics are *None, Number of Tokens owned, Allowlist*. *None* allows everyone to create a proposal. The *Number of Tokens owned* requires the proposal creator to hold a specific number of tokens; while *Allowlist* means that someone or a group has to add the member that wants to create a new proposal to the Allowlist.

Governance Voting is fully On-Chain: This dimension represents the ultimate goal of a DAO: Complete decentralization on a Blockchain. Every governance step is performed on a Blockchain, and no part is handled off-chain. Our taxonomy allows the characteristics *Yes* and *No* for this dimension.

Governance Voting Power: We define how voting power is distributed in a DAO with this dimension. It can either be the *Number of Tokens Owned, Number of Tokens Staked, or Per Individual*. With the *Number of Tokens Owned,* the voting power is directly correlated to the weight of the vote of a DAO member. With the *Number of Tokens Staked*, the voting power results directly from the number of Tokens a DAO member. *Per Individual* describes a case where a few individuals each have the same voting power.

Governance Voting Limits: A DAO can also impose restrictions on the voting power of a single DAO member. For example, a maximal number of eligible owned or staked tokens can be set per DAO member. Therefore, we use the characteristics *None* and *Per Address, w*here *none* means no limit'; and *Per Address* the arbitrary limit imposed on each DAO member.

Treasury

In the Treasury, all assets of a DAO are stored. The Treasury can take all possible forms of asset management, like holding many different fungible or non-fungible tokens or even real-world assets. In a DAO, the governance process decides how to effectively use the assets to achieve to goals of the DAO.

Treasury Meta Information – Diversification: The Treasury of a DAO can have many different forms. For example, at the beginning of a DAO, a governance token has been minted and the DAO Treasury contains only its governance token. If the DAO decides to sell some of its governance tokens, the Treasury can diversify with Ethereum or USDT (USD Tether, a typical stable coin). Additionally, the DAO can decide to buy many different tokens, so that the value of the Treasury is not dependent on a single or a few tokens. Therefore, we define the characteristics *None*, *Some,* and *Very*, where *None* means more than 95% are held in the DAOs own governance token; *Some* refers to more than 5%, but less than 25% are held in tokens that are not the own governance token; the characteristic *Very* describes a Treasury where more than 25% of all tokens held are not the own governance token.

Treasury Meta Information – Stakes Token: A Treasury can stake tokens for use cases like monetary gain by taking part in a Proof-Of-Stake algorithm, provision of liquidity to a DeFi Application, or the gain of the staked voting power. However, there is a long list of possible options for staking tokens and most DAOs use many different use cases for staked tokens. Therefore, we introduce this dimension as a flag characteristic with *Yes* and *No* options.

Treasury Meta Information – Capital Gain: With this dimension, we describe how the DAO can increase the funds in its Treasury. We observed three ways: *Token Sales, Services,* and *Investment Returns*. *Token Sales* can be either initial token sales or ongoing token sales. We describe the initial token sale in the Treasury setup dimensions. Ongoing token sales are, for example, team tokens that have been allocated for the team. DAOs can, for instance, define this in their Tokenomics – the key figures of the initial and ongoing token allocation. *Services* can be the sale or the access to software that the DAO owns or provides. Lastly, a DAO can receive *Investment Returns* on its investments in other DAOs that provide services, DeFi applications, NFT collections, etc.

Treasury Setup – Initial Airdrop: There are different ways to distribute the governance tokens initially. One way of performing this distribution is to airdrop tokens to a set of users. *Airdropping* means that the users receive the tokens without paying for them. A group of eligible users for an airdrop can be chosen by selecting users from adjacent organizations, users of typical web3 applications, or previous contributors of the DAO. Our taxonomy offers the flag characteristic *Yes* and *No* for this dimension.

Treasury Setup – Initial Token Sale: Contrary to the *Initial Airdrop,* where the user receives the tokens for free, the *Initial Token Sale* always requires the token receiver to pay for the tokens. Examples of this type of Token Sales are Initial Coin Offerings (ICOs), Initial Exchange Offerings (IEOs), and Initial Decentralized Offerings (IDOs). Since there are countless sales methods, our taxonomy uses a flag characteristic with the values *Yes* and *No* for this dimension.

Inadmissible Characteristics of DAOs

Treasury Type: The *Treasury Type* dimension specifies how DAO members can access the fund. Our taxonomy describes the possibilities of a *Single Owner,* and *Smart Contract*. A single owner has full control over the treasury, whereas a smart contract is governed by a governance system or a group of multi-signature holders.

Treasury is Public: This dimension, with flag characteristics *Yes* and *No,* states if anyone can view the balance and content of the DAO Treasury at any time.

Has Governance Voting Process: The dimensions for the voting process states if there is a governance voting process in a DAO. The available options are *Yes* or *No*.

Has Governance Token: This dimension describes if a Governance Token exists. Without any governance token, a DAO cannot perform formal decentralized governance. We describe it as a flag, offering the options *Yes* and *No*.

Assessment Characteristics of DAOs

Token Holders: Our Taxonomy offers five characteristics for Token Holders within a DAO. We define

$$Token\ Holders = \begin{cases} very\ small & for\ x\ <\ 100 \\ small & for\ 100 \leq\ x\ <\ 2500 \\ medium & for\ 2500 \leq\ x\ <\ 12500 \\ large & for\ 12500 \leq\ x\ <\ 50000 \\ very\ large & for\ x\ >\ 50000 \end{cases}$$

Where $x\ =\ |DAO\ Token\ Holders|$

Community Participation: The Taxonomy uses five characteristics for activity in a DAO. We define

$$Participation = \begin{cases} None & for\ x\ =\ 0\% \\ Some & for\ 0\% <\ x\ <\ 25\% \\ High & for\ 25\% \leq\ x\ <\ 90\% \\ Very\ High & for\ 90\% \leq\ x\ <\ 100\% \\ Full & for\ x\ =\ 100\% \end{cases}$$

Where $x\ =\ \frac{|DAO\ Average\ Active\ Voters|}{|DAO\ Token\ Holders|}\ \times\ 100\ in\ Percent$

None, Some to Very High, and Full each create very distinct categories. However, with Some to Very High included in the taxonomy, a more granular distinction about some types of DAOs can be performed.

Treasury Size: Our taxonomy offers five characteristics for Treasury Size in a DAO. We define

$$Treasury\ Size = \begin{cases} none & for\ x\ =\ 0 \\ small & for\ 0 <\ x\ <\ 5000000 \\ medium & for\ 5000000 \leq\ x\ <\ 50000000 \\ large & for\ 50000000 \leq\ x\ <\ 500000000 \\ super & for\ x\ >\ 500000000 \end{cases}$$

Where $x\ =\ Treasury\ size\ in\ US-Dollar$

We developed this distinction, performing a semantic partitioning of our dataset with clustering and looking for breakpoints, where the structure of a DAO changes drastically. Furthermore, Treasury size does not include Total Value Locked (TVL) but only the number of tokens useable by the DAO.

Governance Process Portal: This dimension allows us to measure the maturity level of a DAO. The possible characteristics are *Standard Software, Custom,* and *None*. *DAOs* use *Standard Software* to kickstart the governance quickly. Once DAOs mature, more *Custom* solutions are deployed. We have found that all DAOs that use *Standard Software* in our sample use a tool called Snapshot (Snapshot Labs 2022). *None* means that voting is not supported by special software and must be performed manually.

Has Legal Entity: Specifies whether a DAO has an underlying legal structure.

Underlying Blockchain: States the underlying blockchain hosting the smart contracts of the DAO.

Application and Validation of the Taxonomy

We perform agglomerative clustering on our dataset to apply the taxonomy to a use case. We receive combined characteristics that build categories of DAOs that are not set arbitrarily but are calculated with scientific methods. We have performed agglomerative clustering, using the Wards method, to reach this goal; this is because it has worked well for analyzing other taxonomies and is the appropriate choice for categorical data (Fischer et al. 2020; Gimpel et al. 2018; Hofmann et al. 2021). Our selection of the number of clusters was supported by calculating the Silhouette score (Berkhin 2006), the Davis-Bouldin score (Davies and Bouldin 1979), and the Dunn Index (Dunn 1974). These measures evaluate the quality of the clustering results. The silhouette score is proportional to the inter-cluster distance, while the Davis-Bouldin score represents the average similarity measure of each cluster with its most similar cluster (Pedregosa et al. 2011). According to both scores, five to eight clusters would be optimal. Five clusters yield 0.38 for the Silhouette coefficient and 2.1 for the Davis-Bouldin Score, respectively. We also implemented the Elbow Method, to help us find the correct number of clusters (Pedregosa et al. 2011). From Figure 2, we can see that the optimal number of clusters, according to the Elbow score, is k=6. Semantically, five clusters make the most sense. To confirm this, we did a visual approach using the Dendrogram in Figure 4 by looking at the different existing clusters and how they split when a new cluster is added. We have also done this with all experts in the interviews to find the most fitting number of clusters resulting in five as the most named.

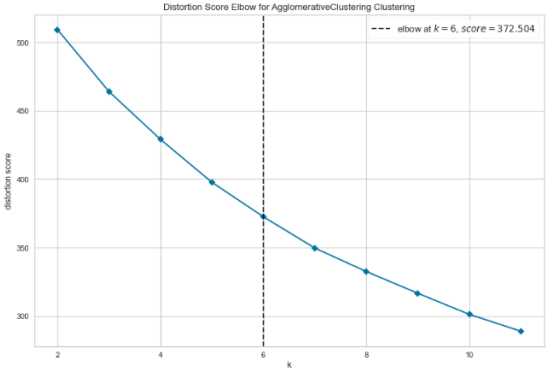

Figure 2. Distortion Elbow

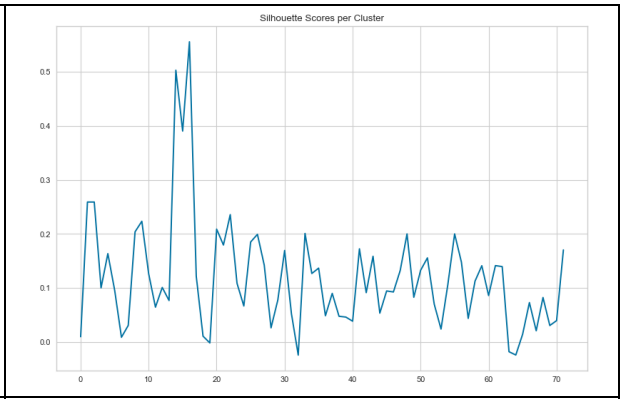

Figure 3. Silhouette Scores

Next, we describe the five semantically different clusters and highlight their unique characteristics.

Cluster Red: Off-Chain Product and Service DAOs with Community Focus

Product and Service DAOs have an open community. Their purpose is to build products and manage them. The primary purpose of participating in the community as a token holder is to profit from a price increase of the governance tokens. Contributors of the DAOs are rewarded with governance tokens. To participate in the governance process, tokens are needed, but the process is open to the public. Voting requires governance tokens. Creating a proposal is restricted to members that own tokens. Governance decisions are executed manually by a group of multi-signature holders governing the treasury. The initial token distribution is done with an initial airdrop and the DAOs gain capital through their services.

Cluster Green: On-Chain Product and Service DAOs

On-chain product and service DAOs also have an open community. Users actively participate in the DAO for community aspects. The business models of these DAOs are a service on the chain, which charges the user fees; and these fees are then used to increase the price of the governance token. The governance process is restricted to members that own a certain number of tokens and the weight of a single vote is determined by the number of tokens owned. The execution of the governance vote is done completely on-chain and does not require a team member to act.

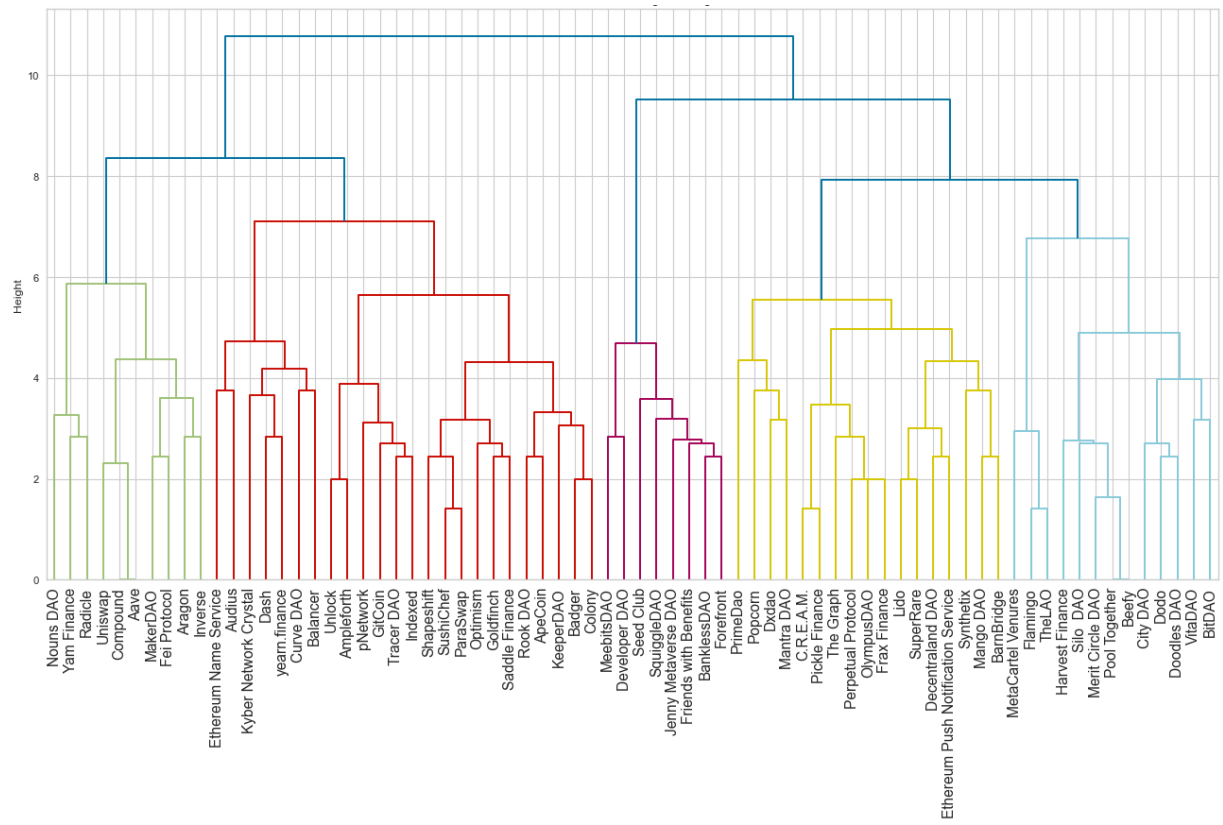

Figure 4. Resulting Hierarchical Dendrogram

Cluster Blue: Investment-focused DAOs

The primary purpose of investment-focused DAOs is investing or fundraising. Members have to own tokens to participate in the governance process and also have to own tokens to create a proposal. All members are known by their pseudonyms and gain monetary value by holding their governance tokens. This rises in price when the investment returns of the investments actioned by them through their governance process result. An initial token sale allocates the initial token distribution. The treasury of investment-focused DAOs is very diversified. Their community is open to the public and contributors are rewarded with other tokens.

Cluster Purple: Networking-focused Community DAOs

The primary purpose of networking-focused community DAOs is community building and engagement. In turn, the primary purpose of community members is to connect with the community, which is gated by token ownership. Members of the community are known by a pseudonym. These communities gain capital by selling their governance token. The initial token distribution is either done with an airdrop or with a token sale. Their governance process is not visible to the public and requires the ownership of tokens to participate. Only members on an Allowlist can create new proposals.

Cluster Yellow: Off-Chain Product and Service DAOs with Investor focus

Product and Service DAOs have an open community. Their purpose is to build products and manage them. The primary purpose of participating in the community as a token holder is to profit from a price increase of the governance tokens. Contributors of the DAOs are rewarded with other than the governance tokens, mostly stable coins or Ethereum. To participate in the governance process, tokens are needed, but the process is open to the public. Voting requires governance tokens. Creating a proposal is restricted to

members that own tokens. Governance decisions are executed manually by a group of multi-signature holders governing the Treasury. The initial token distribution is done with an initial token sale and the DAOs gain capital through their services.

		Dimensions	Cluster Red (33%)	Cluster Blue (18%)	Cluster Purple (11%)	Cluster Green (13%)	Cluster Yellow (23%)
Community	Membership	Access	Open	Open	Token Ownership	Open	Open
		Type	Profit from Tokens	Profit from Tokens	Community	Community	Profit from Tokens
		Is hierarchical	No	No	No	No	No
		Anonymity	Pseudonymous	Pseudonymous	Pseudonymous	Anonymous	Pseudonymous
	Meta	Contributor Rewards	Governance Token	Other Token	Other Token	Governance Token	Governance Token
		Purpose	Product Building and Management	Investing or Fund Raising	Community Building and Engagement	Product Building and Management	Product Building and Management
Governance	Token	Type	Singular	Singular	Singular	Singular	Singular
		Supply Cap	Capped	Capped	Capped	Capped	Capped
	Process	Entry Barriers	Ownership	Ownership	Ownership	Ownership	Ownership
		Is fully Public	Yes	Yes	No	Yes	Yes
		Execution	Manual	Manual	Manual	Automatic	Manual
		has Proposal Creation Restricted	#Tokens Owned	#Tokens Owned	Allowlist	#Tokens Owned	#Tokens Owned
	Voting	is fully On-Chain	No	No	No	Yes	No
		Power	#Tokens Owned	#Tokens Owned	#Tokens Owned	#Tokens Owned	#Tokens Owned
		Limits	None	None	None	None	None
Treasury	Meta	Diversification	None	Very	None	None	None
		Stakes Tokens	Yes	No	No	No	Yes
		Capital Gain	Services	Investment Returns	Token Sales	Services	Services
	Setup	Initial Airdrop	Yes	No	No	No	No
		Initial Token Sale	No	Yes	No	Yes	Yes

Table 4. Results of the DAO Clustering

Conclusion and Outlook

Even though DAOs have been around since 2014 (Buterin 2014), they have only recently started receiving attention from the general public. Since then, very little research has been conducted on the inner workings of DAOs; while no research at all has been done regarding data-driven taxonomies. This situation has meant that very little is known about the different potential dimensions of DAOs and which characteristics DAOs may potentially adopt. Since DAOs have emerged as a new type of organization, information system researchers, developers, and investors currently experience difficulty in understanding the different forms of DAOs. To bridge this research gap, we have developed a data-driven taxonomy of DAOs.

We collected data on 102 organizations, of which 72 qualified as DAOs under the definition we used in this work, as derived from Rikken et al. (2021). Following the approach of Nickerson et al. (2013), we performed several empirical-to-conceptual iterations, in order to build our data-driven taxonomy. In addition to the empirical-to-conceptual iterations, we performed conceptual-to-empirical iterations. One of the iterations received its conceptual data from a design space that we defined, using design space constraints (Biskjaer et al. 2014). Finally, we performed a qualitative validation with two rounds of semi-structured expert interviews. The resulting taxonomy contains three main categories, seven sub-categories, 20 dimensions, and 53 characteristics. While we do not consider this taxonomy final, as the field is still moving very fast and new DAOs are founded every day, we have proven that it is solidly based. We have done this by performing agglomerative clustering on our dataset, which we then fitted into the taxonomy. The clustering resulted in five distinct clusters, each describing a different type of DAOs instead of nine or more, as commonly referred to in the relevant blogs (Cointelegraph 2022).

We contribute to both theory and praxis by providing a non-intuitive data-driven taxonomy that can be used for further research and the creating or fine-tuning of DAOs. We contribute to the descriptive knowledge of a relatively new research area by providing technical descriptions, to the best of our understanding of all the dimensions a DAO could potentially have. This fosters general expertise on DAOs and their inner workings within the research community. The clustering allows researchers to target a specific type of DAO as every cluster we have found contains a set of DAOs that each follow the same goal. With this, a researcher can define dependent variables according to a cluster of DAOs and does not have to work with DAOs as a grand unit. DAOs in general are very diverse and cannot easily be used for further research into the success, maturity, or completeness of a DAO, however, we argue, that with our taxonomy and the clusters it makes this kind of research more accessible as a group of DAOs can be targeted instead. Practitioners can leverage this framework to build applications that score the maturity, performance, completeness or other key value indicators to provide insights into DAOs for investments or general selection criteria.

While we have made a considerable effort to obtain high-quality, extremely accurate data, we have to acknowledge that the material provided on the websites or whitepapers of DAOs, as well as in their technical documentation, do not always represent actions that have actually taken place in DAOs. For example, we identified an organization that claimed to have a decentralized execution process. Still, after looking further into its smart contracts, we found out that a single user issued all of its transactions. In this case, we fixed the data point; but the fact remains that we cannot, in the case of some characteristics, generally look this deeply inside an organization and must rely, instead, on its published materials. We consider this to be a critical issue for further predictive research and wish to highlight it specifically. For our taxonomy, we would suggest that a few single invalid characteristics in the source dataset did not affect either the resulting taxonomy or the clustering. Furthermore, all of the DAOs we examined were mostly based on the Ethereum blockchain. Once established, DAOs might take different forms on other blockchains due to possible new features, which should be noted to expand our taxonomy in the future.

DAOs can potentially disrupt traditional organizations through their flat hierarchies and direct ownership by their members. They will take many different forms in the future in many use-cases, such as crowdfunding, company structure, employee ownership, compensation for work, and like-minded communities. Many more DAOs will be created in the future, taking over many organizations in the crypto-space. They will look different from the DAOs we currently see; so new, ongoing research that expands this taxonomy will be needed.

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