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EXECUTIVE SUMMARY OF THE THESIS

Alternative Financing Mechanisms: DeSci and DAOs

TESI MAGISTRALE IN MANAGEMENT ENGINEERING – INGEGNERIA GESTIONALE

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1. Introduction

Why is Vitalik Buterin, founder of Ethereum, speaking at a conference focused on pharma and life sciences? The answer is in the name of the event: DeSci London, where DeSci stands for *Decentralised Science*. The scientific and the crypto world have never been closer. A relevant problem in the pharmaceutical industry is related to R&D and drug development funding, intended as financing the process of discovering potential new drugs and bringing them to patients. This results in unsustainable pricing for medicines or, even worse, overlooking particular diseases, leaving patients without a cure [1], [2]. DeSci has the potential to solve the problem through DAOs, blockchain-based Decentralised Autonomous Organisations [3]. DAOs enable community-driven, decentralised funding, empowering a more open and fruitful R&D environment [4], [5]. Besides the ideological ambition of democratisation, DAOs could represent an alternative funding mechanism for pharmaceutical research and development. However, the worldwide literature has not explored the matter in detail: few papers are available on the broad DeSci topic, and no contribution is focusing on the so-called BioDAOs as a funding channel for drug development. This study has the objective to gain a deeper understanding of BioDAOs as an alternative financing mechanism. Specifically, the two research questions driving the analysis are:

RQ1: *What are the distinctive features and the challenges of BioDAOs as alternative funding mechanisms for financing life sciences and pharmaceutical R&D projects?*

RQ2: *How do BioDAOs relate to other industry actors, such as established pharmaceutical corporations and venture capital funds?*

To address these questions, the study involved a single case study methodology, with VitaDAO as the unit of analysis. The research was based on a series of semi-structured interviews with founders, other members, and key stakeholders of the organisation. Moreover, thanks to its open nature, I entered the DAO by purchasing 10 VITA tokens (~12 USD, representing 0.000072% of voting rights), to gain first-hand experience on how the community interacts and, in general, how the organisation works from the inside.

2. Background

2.1 Drug Development

2.1.1 Pharmaceutical R&D Process and Actors

The main contribution in the earliest phases of the drug development process – i.e., drug discovery, pre-clinical research and the first clinical trials - is from academic researchers and pharmaceutical startups [6], [7], [8]. The latest stages - i.e., finalising clinical trials and development - are primarily conducted by research pharmaceutical companies, which focus there to reduce risks [9]. The main investors are governments and philanthropic organisations for the early stages, pharmaceutical companies and venture capital funds for late-stage development [10].

2.1.2 Faults of the Drug Development Industry

(i) Pharmaceutical R&D is an extremely long, risky and expensive investment: duration of around 10 years [11], 1:10,000 success rate [12], and costs in the order of billions [13]. (ii) The efficiency of drug development has halved every 9 years since 1950 [11]. As a consequence, the industry focuses on the most profitable drugs, regardless of healthcare and innovation outcomes [6], [14]; (iii) The intellectual property system compromises innovation, pushing players toward additive research [15] and hindering knowledge sharing [6]; (iv) Traditional funding does not target several therapeutic areas because too risky and unprofitable: neglected diseases, too rare to invest [16], and the *Valley of Death*, which covers the earliest and riskiest stages of drug development until clinical trials [2].

2.2 Blockchain and Smart Contracts

Blockchain is a technology which records all the transactions between parties in a decentralised ledger, in a transparent and permanent manner [17], ensuring a single source of truth shared across different agents [18]. Blockchain's key features are (i) trustless disintermediation [19], (ii) immutability, since data on the blockchain cannot be compromised, avoided or reverted [20], [21], and (ii) transparency, thanks to the public ledger [17], [22]. Blockchain enables *smart contracts*, pieces of code which execute commands autonomously in the form of "if this, then that". In this way, contracts can be enforced automatically, without the need for a trusted third party [23], [24].

3. Systematic Literature Review

3.1 Process

The first step of this research is a SLR on Decentralised Autonomous Organisations, to gain comprehensive knowledge of DAOs and assess the gaps in the current state of the literature. It started with a search query on Scopus, resulting in a pool of 946 papers. The papers were screened first based on their abstract, and then by reading their full text. After the screening phase, 66 articles were considered eligible for the SLR. These papers were integrated with 3 documents from the grey literature, useful given the internet-based nature of DAOs, resulting in a total set of 69 eligible articles. The results of the SLR have been structured into an overview of Decentralised Autonomous Organisations, addressing definitions, origins, characteristics, and applications in the healthcare industry. Finally, a gap in the literature about DeSci has been identified, triggering the research presented in the following sections of the paper.

3.2 Decentralised Autonomous Organisation (DAO)

3.2.1 What is a DAO?

In the literature, there is no agreed definition for DAOs [25]. Ethereum's founder describes them as virtual entities whose shareholders have the right to spend their funds and modify their code [26].

A DAO is…

- …an *organisation.*

  DAOs are made of people collaborating for a common purpose [25], [27].

- …a *decentralised* organisation.

  DAOs are supported by a blockchain, which enables transparent and decentralised governance [27]. By purchasing tokens, users are not just owners but also managers of the DAO, and every decision must gain a majority consensus through a token-based vote to be applied [28], eliminating hierarchies [29].

- …a decentralised *autonomous* organisation.

  DAOs exploit smart contracts to automate the execution and enforcement of every decision made [30]. In this way, DAOs do not centralise power into the hands of humans [27], but

employ what is referred to as "lex cryptographia", where" "code-is-law" [24].

3.2.2 DAO Timeline: *history and where we are*

The concept of DAOs emerged idealistically in the late 2000s, but at that time, the technology to transform the idea into reality was missing [31], [32]. Blockchain breakthrough made DAOs come to life: in 2014, Buterin introduced the term DAO as we intend it today [31]. In 2016, the first DAO based on Ethereum's smart contracts was launched [33]: "The DAO", a decentralised fund where users voted on investment opportunities. Unfortunately, it made history in the renowned "DAO Hack", with $ 50 million stolen by exploiting a fault in the code. This taught the world DAOs' security risks [34]. In the 2020s, the number of active DAOs increased sharply [35]. Experimentation is now focusing on combining DAOs with artificial intelligence, to strengthen the autonomous component [36], and metaverse technologies, enabling the creation of parallel societies [37].

3.2.3 Exploring Decentralised Governance

The four fundamental building blocks of a DAO's decentralised governance are *(i) the token, (ii) voting, (iii) proposals,* and *(iv) community incentives.*

(i) The *token* is the means to administer a DAO: it is an evolution of traditional corporation shares [38], enabling the decentralised management of the entity through token-based voting [30]. Security tokens grant investors a share of the entity's profit [32]; pure governance tokens do not grant direct returns, but provide the owner with governance rights to administer the organisation [39].

(ii) Token holders exercise their rights through token-based *voting*. The literature mentions several voting protocols, from simple voting – one-person-one-vote, to complex and meritocratic forms such as reputation-based voting [27], [40].

(iii) Users vote on *proposals* and can also make them first-hand [41], e.g., investment proposals, governance or infrastructural changes [31], [42].

(iv) Decentralised governance enables *incentives alignment* of users creating a *token economy*. Every member holds tokens, unlocking the possibility to design an incentive scheme [43]. Besides the increase in value of the token, users can be rewarded for their contribution, both economically or with voting rights [31], [42].

3.2.4 DAO Benefits

B1: Reduction of agency costs by unifying ownership and control [31], [35].

B2: Increased efficiency through automation of tasks [35], [44], and reducing human errors [31].

B3: Lower barriers to entry and elimination of geographic boundaries: the decentralised and virtual nature of DAOs allow everyone to join [17], [27], [44], from every part of the world [38].

B4: "Wisdom of the Crowd": DAOs benefit from a large and diverse "collective intelligence" [17].

3.2.5 DAO Drawbacks

D1: Security issues and poor crisis management: vulnerabilities could be targeted for economic attacks [45]. Decentralised decision-making slows down crisis management [35], [42], [46].

D2: Privacy issues arising from associations in the public ledger, or by sharing private keys [41], [47].

D3: Coordination and contracting costs arising from the distributed decision-making of DAOs [35], [46].

D4: Low participation and participation barriers: large shareholders can exploit low participation to extract private benefits [35]. Participation barriers exist due to blockchain's complexity [34], [35].

D5: Plutocracy and centralisation risks, where the wealthiest users own the greatest voting power, compromising DAO's democratic nature [37].

D6: Regulatory uncertainty, arising from two areas: the assignment of responsibility in case of disputes with external actors [35], [48], and the token, which could be assimilated to a financial security [35].

3.2.6 DAO Application: Decentralised Science

The applications of DAOs in the pharmaceutical industry have not been explored in detail, especially in relation to the ground-breaking phenomenon of Decentralised Science (DeSci). DeSci leverages DAOs to solve problems in the scientific ecosystem, democratising funding, fostering open innovation and prioritising healthcare outcomes over profits [4], [49]. One of the main potentials for DeSci is creating a paradigm for decentralised drug development funding, where BioDAOs' token holders democratically select projects to finance, with the aim of advancing research in a given therapeutic area [4].

4. Case Study Research

4.1 Methodology

A holistic single case study was selected as the most appropriate method [50], especially given the novelty of the topic and the relevance of people composing Decentralised Autonomous Organisations. The unit of analysis is VitaDAO, a DAO focused on longevity research. It was selected since it is among the first BioDAOs, and the only one to be fully operational. Moreover, it is the only DAO in history to be backed by an established pharmaceutical company, i.e., Pfizer. Therefore, VitaDAO is currently taken as a reference model for other BioDAOs in the making.

The case study research was based on a series of semi-structured interviews with a diversified panel including founders, members and other key stakeholders of VitaDAO. Interviews data were combined with documents of the organisation, such as its whitepaper and its public governance forum, and some insights from my personal experience inside the DAO. Every interview was recorded and analysed through a structured coding procedure [51], from which four main themes emerged. Findings were structured into a narrative framework to provide a detailed overview of this novel and complex organisation form.

4.2 VitaDAO Case Study

Theme 1: Purpose and Stage of Lifecycle

VitaDAO is a BioDAO with the ultimate purpose of *advancing longevity research*. The two practical objectives of VitaDAO to achieve that final purpose are: *(i) bridging the Valley of Death* and *(ii) democratising access to drug development*. *(i)* VitaDAO primarily invests in early-stage projects in the Valley of Death. It aims to fill this funding gap first-hand, de-risking these projects for late-stage investors. *(ii)* The second pragmatic objective is democratising access to drug development for everyone interested. The industry is currently extremely closed: patients cannot contribute to decision-making, and pharmaceutical companies decide what research to advance, prioritising capitalistic aspects; moreover, investments are exclusively allowed to institutional investors, (e.g., VC funds). VitaDAO aims at opening the process to patients with a bottom-up approach, which would shift stakeholders' interests toward a more aligned framework [3], prioritising healthcare outcomes: *"How would the IP for insulin be managed if owned by diabetics?"* (Interviewee #5).

VitaDAO stands in an early stage of its lifecycle. It went fully operational in June 2021, issuing VITA tokens. After the first year spent on structuring itself, the DAO recently started operating in a consolidated way. The next steps involve increasing the size of the community and advancing invested projects toward commercialisation.

Theme 2: Unique Characteristics

2.1 Open and Borderless Organisation

VitaDAO is open and borderless: everyone around the world can join in an extremely simple way: in a few minutes, a potential user can access VitaDAO's Discord, a private server where the community discuss informally and proposes ideas for the DAO. *"Nobody was hired into the DAO, everybody just kind of shows up and says he wants to help"* (Interviewee #3). The open and virtual nature of the DAO makes it a valuable opportunity for professional development.

2.2 Bottom-up Drug Development

VitaDAO enables *"Bottom-up Drug Development"*, leveraging decentralised governance in a flat organisation. Everyone in VitaDAO can contribute by scouting and proposing investment opportunities, helping in the assessment of deals and, finally, voting for proposals. Phase 0 proposals start informally on Discord. If they gain traction, they are transferred to Discourse, VitaDAO's public governance forum, for a more formal discussion as Phase I proposals. Feedback polishes the idea which becomes a Phase II proposal. If considered worth it, a Phase III proposal is published on Snapshot, a platform for token-based voting, with a one-token-one-vote protocol. VitaDAO's members and stakeholders are confident that this bottom-up method, as opposed to the top-down of traditional systems, could shift the focus of investments on healthcare outcomes rather than profits.

The investment process is collaborative and community-driven. Following [52]'s process for venture capital investing: (i) deal origination comes from three sources: inbound; outreach, thanks to sourcing squads internal at VitaDAO; referral by any user in the community. (ii)

VitaDAO's screening phase is milder than traditional VC since its large community allows the parallelisation of more deals. (iii) A deal squad is created around a potential deal, which sends a project document to a panel of senior independent reviewers. If their feedback is positive, the proposal is then published as a Phase II on Discourse, to be discussed with the community and, eventually, to be approved with a formal Phase III token-based vote. (iv) The deal structuring is undertaken by the deal squad and a team from the legal working group. (v) After the deal is done, the community assists the portfolio projects with bottom-up feedback from interested users. The speed of the deal flow is higher than the establishment: the average time elapsed between deal origination and execution is a few weeks, with the shortest time around two weeks.

The DAO is flat and without hierarchies: it is organised into working groups (WGs) - competence areas to which members are allocated based on interests and background. Each WG has a Steward, a highly committed and experienced contributor who facilitates its operations.

2.3 "Wisdom of the Crowd"

The distinctive characteristic of VitaDAO compared to the establishment is the *"Wisdom of the Crowd":* VitaDAO can count on more than 9,000 users worldwide, who contribute first-hand toward the shared goal scouting investment opportunities, providing feedback on due diligence and improving operations. Relying on a diverse community in terms of country, culture, background and mindset facilitates taking unbiased decisions. The result is what interviewees called "the ultimate peer review".

2.4 Token-based Business Model

The presence of VITA tokens aligns incentives by *unifying ownership and control*. The token is a governance token: it does not grant holders financial returns such as dividends. The DAO follows the so-called *"Sustainability Loop"* principle, where returns are looped back to the DAO with the attempt of creating a self-sustained financing vehicle. This enables the construction of a community which truly cares about the longevity cause, prioritising healthcare outcomes over profits. In detail, token holders provide funding to the organisation, which finances R&D projects in exchange for ownership of their future intellectual property. Projects are pushed across the Valley of Death and, if successful, they can be acquired or licensed by later-stage investors such as Big Pharma corporations. All the proceeds are looped back into the DAO and used to fund future research. An important operating component for VitaDAO is the IP-NFT protocol, which enables intellectual property tokenisation, making the traditionally rigid asset liquid and tradeable [4].

Theme 3: Obstacles

3.1 Coordination Struggles

VitaDAO is not free from *coordination struggles*, which reduce efficiency, slowing down decision-making. *"The first angel investor in Google wrote them a check on the spot, 100 grand. You can't do that in DAO. Right?"* (Interviewee #9)

3.2 Scepticism and Participation Barriers

The novel crypto nature of DAOs, which is complex and subject to hype and misinformation, can *raise concerns and scepticism in the industry*: the CEO of a startup funded by VitaDAO argued that they had to educate the board before accepting the investment. The problem is greater with tech transfer offices, which must approve funding received for academic research. However, VitaDAO is aware of the issue, and mitigates uncertainties by improving its communication – even through one-to-one meetings with the industry -, focusing on the community-driven nature of the DAO, more than its crypto back end.

3.3 Regulatory Struggles

DAOs stand in a *grey legal area*: crypto regulation can impact VitaDAO's operations and, ultimately, its survival. Struggles arise in two main areas: (i) the *practical transfer of funds to investee projects* and (ii) a *more general sentiment of uncertainty towards regulation*. (i) For fund transfers, VitaDAO relies on two traditional companies as counterparties for the transactions: for equity deals, the DAO established a non-profit Foundation in Canada; For IP-NFT deals, Molecule, the startup which provides the protocol, mediates the transaction. (ii) To hedge against the uncertainty related to crypto regulation, VitaDAO features a conservative structure, with a governance token design, and with operations detached from the crypto ecosystem. As such, The DAO could react to regulatory issues with design changes, without losing its most valuable asset: the community.

Theme 4: Relationships with the Establishment

VitaDAO did not enter the pharmaceutical industry to compete with the establishment, but rather *to collaborate*. The benefits of a partnership between VitaDAO and the establishment – a VC or a pharmaceutical corporation – are bilateral. The establishment benefits from accessing the largest longevity community in the world and its wide and detailed deal flow, opening a channel for potential projects to be acquired after the DAO pushes them over the Valley of Death. From VitaDAO's side, partnerships with the establishment provide (i) exit opportunities; (ii) strategic knowledge and expertise; and (iii) a positive signal to the industry.

The most remarkable concept emerging from the research is that VitaDAO aims at creating a collaborative ecosystem where different actors join forces around an asset to ensure its full development, and then share the benefits of their work. Every actor benefits from collaboration: universities accept VitaDAO's funds to overcome the Valley of Death; a pharmaceutical company or a VC partner with VitaDAO to open up future investment opportunities. In this way, a therapeutic overlooked by the traditional system could prove successful and reach the market, with tangible healthcare outcomes. This partnership ecosystem is enabled by DAOs, acting as a collaborative platform, and IP-NFTs, which enable the fractionalisation of IP ownership and its distribution among the contributors.

In other words, DAOs complement the gaps in the industry and provide a platform in which all the different actors can collaborate on a different phase of the long and complex drug development process. This is an important influence of Open Science on BioDAOs and DeSci: from traditional siloes and competition to an open, collaborative and decentralised drug development.

5. Conclusions

5.1 Main Findings

[RQ1] BioDAOs target a therapeutic area with the aim of aligning incentives in the traditional system. VitaDAO's specific purpose is bridging the Valley of Death and ultimately advancing research and development in the field of longevity. BioDAOs' bottom-up drug development, combined with a business model which enables the equal participation of a wise community of users committed to the cause, aligns incentives toward healthcare outcomes, rather than profits. This brings financing to overlooked projects that would otherwise be stuck in the Valley of Death, hindering pharmaceutical progress. However, the non-traditional nature of DAOs can raise coordination inefficiencies when timely decisions need to be made, scepticism with the industry not trusting the blockchain world, and concerns related to the incoming cryptocurrency regulation which could undermine the operations of BioDAOs.

[RQ2] Coherently with their purpose, BioDAOs such as VitaDAO target early-stage, risky projects in the Valley of Death, filling a gap in the traditional system: the more projects BioDAOs manage to bridge across the Valley of Death, the more investment opportunities for the establishment. Hence, BioDAOs are not competitors of the establishment. On the contrary, they aim at partnering with the industry. The result is that different stakeholders can join forces on the end-to-end development of a potential therapeutic, with DAOs serving as a collaboration platform for decentralised drug development. It is a potential win-win-win situation: drug development can become open, decentralised, and collaborative.

5.2 Contributions

This paper contributes to the extant literature by consolidating two topics - drug development's faults and DAOs - and analysing their intersection, expanding studies on Decentralised Science. The research provides an overview of the most exemplary BioDAO, a financing mechanism which is not detailed in the current state of literature. More specifically, this research contributes to addressing future research proposed by [1], exploring additional funding mechanisms for pharmaceutical R&D, and extending DeSci's nascent literature, initiated by [4] and [49].

From an entrepreneurial and managerial standpoint, the study offers an exhaustive overview of DAOs, presenting working mechanisms, advantages and disadvantages of the technology: this provides a toolbox for entrepreneurs willing to start a BioDAO. Regarding the establishment, pharmaceutical corporations and venture capital funds could

assess the advantages of partnering with a BioDAO, while universities could discover a novel mechanism to fund their research.

About the social side of contributions, DAOs democratise access to drug development, opening an extremely closed and elitarian sector to anyone willing to contribute, fostering global collaboration and revolutionising the job dynamics with flexibility and value-based rewarding. This is expected to push the system toward more equitable pharmaceutical progress, taking into account the interests of the global population rather than profits.

From a regulatory perspective, even if BioDAOs tend to build a conservative structure with pure governance tokens and detaching real-world operations from cryptocurrencies, the technology is still in a grey legal area. Regulation is necessary to mitigate the uncertainty around the technology. In addition, the noble goal of BioDAOs should be considered by authorities when designing a regulatory framework.

5.3 Limitations and Further Research

This research is not free from limitations. The single case study methodology, adopted since VitaDAO was, at the time of the study, the first and only BioDAO to be fully operational, limits the generalisability of the results. A second area of limitation is related to the early stage of BioDAOs. Currently, there are no BioDAOs which pushed projects across the Valley of Death, posing serious uncertainty on the economic sustainability of these alternative funding mechanisms.

Further research on the topic could extend the investigation to other BioDAOs once the landscape makes it feasible. In addition, the concept of plutocracy in BioDAOs could be explored to analyse relationships between centralisation and the outcomes of the funding mechanism. Finally, a computer science and legal perspective could be adopted to analyse the topic, especially focusing on the IP-NFT protocol, a complex matter with the potential to be applied to other industries.

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