Project Leadership and Society 4 (2023) 100102

Contents lists available at ScienceDirect

Project Leadership and Society

journal homepage: www.sciencedirect.com/journal/project-leadership-and-society

Empirical Research Paper

Organizing projects with blockchain through a decentralized autonomous organization

Florian Spychiger *, Michael Lustenberger, Jens Martignoni, Lukas Schädler, Patrick Lehner

Institute of Organizational Viability, School of Management and Law, Zurich University of Applied Sciences, Winterthur, Switzerland

ARTICLE INFO

Keywords:
Project management
Blockchain
Decentralized autonomous organization (DAO)
Decentralization
Action design research

ABSTRACT

Blockchain and its related concept of decentral autonomous organization (DAO) is starting to influence project management. But how might project management supported by blockchain technology look like? And how would such a new form change and affect traditional project management? Not many concepts have been designed or even implemented yet. We chose an experimental framework to answer the first aspects of these questions. We developed a Decentralized Autonomous Project Organization (DAPO) and conducted an experiment to study the impact of blockchain on traditional project management. We show that such a blockchain-based approach can support the management of simple projects. Further, a fair and clear incentive scheme seems crucial and influences the way team members engage in the work. Also, more decentralized project management increases the importance of social aspects-related project management principles such as teamwork, self-organization, and cultural aspects, while principles related to budget, objectives, and schedule remain unchanged.

1. Introduction

Project management is a complex and multidimensional activity that is intended to work out a path toward something new (Armitage, 2002). At the very core of the most proven ("conventional") methods of "how to do this successfully" there is a simple concept: "plan before doing" (Wideman, 2009a, p. 2). But this was not successful for all types of projects so there were, especially in recent years, a greater variety of concepts and methods developed to ensure that projects can be carried out successfully. Most have been invented by practitioners through business needs or for specific circumstances[1] An important and ongoing discussion is thereby the use of more traditional predictive concepts versus recently developed adaptive methods, as well as the successful combination of both as hybrid approaches (Hanif, 2011). Lately, the question of what role digitalization could play in the (re)organization of projects has also been raised more frequently (e.g., Marnewick and Marnewick, 2022; Wu, 2022).

Recently, there have been proposals made to use blockchain as a tool for supporting or even substituting project management (e.g., Pastor et al., 2018; Renwick and Tierney, 2020; Das et al., 2022). Blockchain technology was introduced by Satoshi Nakamoto in 2008 as the underlying technology for Bitcoin (Nakamoto, 2008). Since then, technology has been developed to function as a decentralized infrastructure (Buterin, 2016) and has received attention from businesses and academies for its potential to digitalize economies and societies (Tapscott and Tapscott, 2017; Iansiti and Lakhani, 2017; Lustenberger et al., 2021). However, studies with respect to the role of blockchain technology in project management remain largely either conceptual or very technical.

A very promising avenue for organizing projects differently is a decentralized autonomous organization, or DAO (Hassan and De Filippi, 2021). Such organizations are implemented on public blockchains and have all rules encoded. People can then interact with the DAO and are guided to make decisions in a democratic way (Spychiger and Lustenberger, 2022).

However, it is unclear how such a new blockchain-based approach might influence and change traditional project management. In their study on the influence of digitization on project management, Marnewick and Marnewick (2022, p. 9) conclude that currently "specific

* Corresponding author.
E-mail addresses: florian.spychiger@zhaw.ch (F. Spychiger), michael.lustenberger@zhaw.ch (M. Lustenberger), jens.martignoni@zhaw.ch (J. Martignoni), lukas.schadler@zhaw.ch (L. Schädler), patrick.lehner@zhaw.ch (P. Lehner).

[1] Interestingly enough, project management methodologies are named and compared mostly by practitioners or project management software developers, like https://www.projectmanager.com/blog/project-management-methodology or https://crm.org/news/project-management-methodologies or https://thedigitalprojectmanager.com/projects/pm-methodology/project-management-methodologies-made-simple/.

https://doi.org/10.1016/j.plas.2023.100102
Received 6 June 2023; Received in revised form 18 September 2023; Accepted 29 October 2023
Available online 7 November 2023

technologies are only used as a tool to assist the project manager and project team in the day-to-day operational aspects of the project". This study aims therefore to investigate a new form of project management supported by blockchain technology and to conduct experimental indications, that more fundamental impacts of digitalization are reachable. As a benchmark for determining the differences, we have taken traditional predictable project management. There are two research questions for which we try to find answers:

R1. What might blockchain-supported project management look like?

R2. How would such a new blockchain-supported project organization affect traditional project management?

We conduct an exploratory study (see: Saunders et al., 2009) to provide the foundation for future theory-building (Easterby-Smith et al., 2015). To address the research questions, we apply an Action Design Research (ADR) (Sein et al., 2011) approach.

To answer the first question, we developed, implemented, and analyzed a DAO for project management – called a Decentralized Autonomous Project Organization (DAPO). For the second question, we identified nine traditional principles of project management from the literature and used these principles to test in an experimental environment how traditional project management might be affected by a blockchain-supported DAPO.

By answering these questions, we make the following contributions: 1) we depart from mere conceptual models and implement with the DAPO a fully working blockchain-supported decentralized application for project management, 2) we gather important experimental data on how participants react to a blockchain-supported project management environment, and 3) we analyze the implications of the use of blockchain technology on traditional project management through well assessed project management principles.

The article is structured as follows: In the next section, we briefly review the background and development in project management and its current key principles, followed by a section about the related work on blockchain in project management and a description of the research gap. In the methodology section, we explain the ADR approach taken in this study and how we apply it to our work. Next, we derive nine principles of traditional project management. Subsequently, we explain how we designed the decentralized autonomous project management organization used in this study. The findings present the result from the experiment and the evaluations. Our discussion reflects on the findings, their meaning, and the effects of the DAPO on traditional project management. Finally, we draw conclusions, present limitations, and outline future research directions.

2. Background of project management

2.1. Developments in project management

Traditionally, project management has been characterized as something finite and predictable, as "a temporary endeavor undertaken to create a unique product, service or result" (PMI, 2017, p. 4). This statement was strongly underpinned by the organizational research literature over the past 50 years (Winch, 2014). The strengths of this methodology stem from defining the concrete result and predicting all the steps and requirements of a project before the start of execution. However, the limitations of this procedure derive from the observation that projects rarely follow a sequential flow and from the difficulty of determining the requirements for a project in a stable manner. With the publication of the agile manifesto some twenty years ago, traditional project management methodologies were increasingly challenged by agile methods. Agile project management has emerged as a new approach to managing high-risk and complex projects, and has shown to offer higher productivity and quality, as well as more efficient decision-making, on such projects (Salameh, 2014). Agile methods, as well as other methods such as Lean and Six Sigma are based on concepts of operational excellence. They focus on people, their roles and adapting processes to improve production efficiency and product quality (Gubinelli et al., 2022). In the traditional approach, the team dimension depends on goal and budget and is led hierarchically, whereas in the agile approach the team is small and dynamic but usually fixed and is led much more by the requirements of the product, rigid cycles and self-organization. However, agile methods also have disadvantages, such as the difficulty of scaling or an often required physical and temporal proximity of the teams. On the one hand, this has led to very complex support structures and methodologies such as the Scaled Agile Framework (SAFe) for large projects, and on the other hand, it sets limits to decentralized project implementation or requires costly and complex software tools (Barbosa, 2022). The question is therefore, if digitalization in general and blockchain specifically could provide other options with new opportunities for successful project management and for innovative project-oriented organizations (Gemünden et al., 2018). An open research question in this context is how new technologies such as blockchain could improve project management in decentralized organizations and how it would influence dynamic decision-making (Kock and Georg Gemünden, 2016; Lu et al., 2022). Answers could be found by adapting blockchain technology, but since research and knowledge are still scarce, we have opted to start with an experimental approach to provide first indications of what influence and potential a blockchain-based project organization could have on project management. To do so, we start to compare the influence of a new design for project management on the traditional project management methods as a first step. As described in the methodology section later we use the key principles in traditional project management as indicators for measuring the influence of blockchain technology.

2.2. Principles in project management

A principle, according to the Oxford English Dictionary is: "a fundamental truth or proposition that serves as the foundation for a system of belief or behavior or for a chain of reasoning". From this, we can conclude that principles could also serve as a kind of basic assumption for structured, rationally oriented action. Project management, as a process of rational execution of tasks to get to a specified and desired result, is predestined to use principles for this purpose, either by design or by default. These principles are therefore taken by many authors as "the" fundamental rules that should be followed for the successful management of projects (among others Cleland and King, 1986; Lichtenberg, 1989; Bing, 1994; Armitage, 2002; Wideman, 2009a/b; Bekker and Steyn, 2008; Kelly, 2010; Little, 2011; Thompson and Williams, 2018).

Even though principles are essential in guiding activities in project management, the literature remains inconclusive on the position, impact, and use of such principles. While early work advocated a systemic approach (Cleland and King, 1986) to facilitate understanding, later more practical contributions made efforts to define or describe a set of good and convincing principles for successful project management (Bing, 1994; Armitage, 2002; Wideman, 2009a/b; Bekker and Steyn, 2008; Little, 2011). Additionally, the aspects of governance, influence by new tools, and human factors have been given increasing attention (Lichtenberg, 1989; Kelly, 2010; Thompson and Williams, 2018). Broadly speaking, several project management principles have emerged, and these are being used widely in certain sets. In the PRINCE2 standard, principles are explicitly named and used since the revision 2009 (PRINCE2, 2022b). However, most practitioner-oriented methods and handbooks tend to offer best practice advice in the form of "principles". This is reflected in the material available on the internet, where some management-related platforms propose principles as a kind of basic

framework for the methodologies of project management.[2] In the agile world, principles are a kind of funding variables as in the Agile Manifesto (Beedle et al., 2001). The increasing importance of agile methods in self-organizing teams (Hoda and Murugesan, 2016) was also a reason for PMI to revise its standard and to add twelve principles in its newest version (PMI, 2021). Still, there appears to be very little about corresponding theories, and it seems that most principles are based on experimental records and personal experience (Wideman, 2009a/b). As all these examples share similarities, there is a strong assumption that experience delivers enough evidence to use principles as guidelines. The attempt to find "fundamental principles" or "first principles" (Wideman, 2009a/b) has been taken up by the research field in project management but has not yet led to a conclusive result. The question of the right principles can therefore not be answered clearly yet. However, it is possible to identify meaningful and useful sets of principles that have been used successfully in practice.

While such principles constitute a possible base for project management, new technological and organizational developments have the potential to change project management itself and thereby change these principles as well (Morris, 2012; Walker and Lloyd-Walker, 2018). This is described as a development in three waves by Lichtenberg (1989) with a fourth wave emerging now (Sankaran et al., 2022). However, the traditional principles of the "third wave" are still widely used and valid to most practitioners. For our second research question, we also look at possible influences and directions of change that blockchain technology, can bring to the defined project management principles.

2.3. Selection of an "average set of principles"

As mentioned above, it turned out that most of the established principle-sets share many similarities – which aligns with the notion of a best practice. Generally, the principle-sets range from about seven to twelve different principles. From the various sets found in literature research with a focus on established project methodologies, we selected four based on two selection criteria: *first*, they had to be "traditional", which excluded more modern approaches like the Agile Manifesto (Beedle et al., 2001) or the recently introduced principles of project delivery (PMI, 2021); *second*, they should be widely recognized and used by practitioners, and represent different approaches. This excluded principles from commercial providers like Kissflow.[3] Based on these selection criteria the following sets A-D were selected:

A1-A7) The principles built into the PRINCE2 standard as an example of a long-term use in a PM standard (PRINCE2, 2022a)

B1–B8) The earlier (1994) suggestion by John Bing to add principles to the PMI standard (Bing, 1994)

C1–C7) The principles of the Queensland Government - Department of Transport and Main Roads (Queensland Department of Transport and Main Roads, 2022)

D1-D11) The Governance of Project Management Principles of the English Association for Project Management (APM, 2018)

These four traditional sets of principles (in detail see Appendix - Table 3) were our base for identifying a set of "basic principles" that could then be used as a comparative benchmark between traditional project management and the project management enabled by the DAPO. The assumption for deriving traditional project management principles from these sets is that distilling and merging existing, well-used principles would preserve or even improve their relevance. The goal was not to have a perfect set, but rather a set of well-assessed traditional principles. Subsequently, we merged the sets and derived nine traditional project management principles presented in Table 1, which serve as benchmarks or change indicators for further analysis. These distilled principles summarize previous (and contemporary) best practices of project management within the framework of waterfall methods.

3. Blockchain in project management: related work

With the success of the first blockchain "Bitcoin", the underlying blockchain technology began to attract attention and ultimately became heralded in the business world as "the trust machine" (The Economist, 2015). Looking at blockchain technology from an organizational perspective, authors started to highlight the tremendous disruptive potential it could bring to society: a secure platform, where people and organizations can store and exchange value without the need of intermediaries (Iansiti and Lakhani, 2017; Tapscott and Tapscott, 2017; Casey and Vigna, 2018). Within this idea of the "internet of value", two features of blockchain technology came into focus: *first*, the possibility of storing and transacting "real-world" value on the blockchain, and *second*, the ability to store and run whole programs on the blockchain. The first feature refers to the *tokenization* of assets like real estate (Konashevych, 2020; Baum, 2021), equity shares (Roth et al., 2021) or artworks (Lotti, 2019), which actually implies that certain rights (e.g., ownership, a vote) to perform an action (e.g., selling, voting) on an asset are transformed into a transferable but non-fungible data string ("token") on the blockchain (Rozas et al., 2021). The second feature is related to the older concept of "smart contracts" (Szabo, 1996), and refers to computer programs running on the blockchain that can automatically execute a set of predefined functions when triggered by an event (Buterin, 2016).

In their recent study about the implementation of blockchains for projects and project management, Lu et al. (2022) aim to provide a tool

Table 1
Nine traditional project management principles.

No.	Principle	Short Form	Based on
P1	The project must be clearly defined best by the help of a standard like the PMBOK.	The project must be clearly defined	B1; C6; D4
P2	There must be a single leader (project manager) as a single point of responsibility.	There must be a single leader	B2; C4; D1
P3	There must be an informed and supportive management body that delegates appropriate authority to the project manager.	There must be supportive management	A5; B3; C7; D6
P4	There must be a dedicated team of qualified people with clearly defined roles to do the work of the project.	There must be a dedicated team	A3; B4; C1; D2
P5	The project goal and the resulting products must be clearly defined. Measures of success must be predetermined along with the priorities of the stakeholders.	The project goal must be clearly defined	A6; B5; C2; D7
P6	There must be an integrated plan by stages, including authorization points, appropriate methods, and controls, that outlines the action required to reach the goal.	There must be an integrated plan	A4; B6; C3; C5; D3; D5
P7	There must be a schedule establishing the time goals of the project.	There must be a schedule	B7; C6
P8	There must be a budget of costs and/or resources required for the project.	There must be a budget	A1; B8; C6
P9	The organization fosters a culture of improvement, trust and of frank internal disclosure of project information.	The organization fosters a culture of transparency and trust	A2; D10

[2] Examples are: Kissflow, a platform with tools for "better workflow" https://kissflow.com/project/project-management-principles/(accessed 22/02/16) or Wrike, another work management platform https://www.wrike.com/project-management-guide/faq/what-are-the-principles-of-project-management/ (accessed 22/02/16).

[3] https://kissflow.com/project/project-management-principles/.

for practitioners to select the right blockchain to enhance the project's value delivery. Through an in-depth screening of the literature, the authors developed a multicriteria decision matrix to provide a blockchain specification set. The link to project structures and project management was established through a semi-hypothetical case study about construction industry projects. The reason for this auxiliary construct was that the authors found it difficult to substantiate their matrix for real-world project management due to its novelty and the lack of existing literature or case studies. These difficulties in applying blockchain technology in real-world projects and the selection of the construction industry as a hypothetical case should come as no surprise, firstly because much of the current literature on blockchain in project management takes a very conceptual and theoretical approach (e.g., Pastor et al., 2018; Renwick and Tierney, 2020; Das et al., 2022), and secondly because most of the project management literature is concerned with the application of blockchain in the construction industry (e.g., Das et al., 2019; Hargaden et al., 2019; Hewavitharana et al., 2019; Duan et al., 2021; Ni et al., 2021). Others, like Amoah and Oh (2021) and Luong et al. (2021), have developed blockchain-based applications for the management of projects from a technical perspective, which again have never been tested or applied to real-world cases. However, most of these authors generally identify a broad potential for the application of blockchains in project management. For example, Renwick and Tierney (2020) conclude after interviewing a practicing project manager that a blockchain-supported project management system could offer significantly better performance in respect to (i) transparency, (ii) control, (iii) dynamic status updating, (iv) incentives and (v) trust. In their recent literature review, Sonmez et al. (2021) further revealed that the perceived potential of blockchain in project management falls into the four main categories of (i) building trust, (ii) enhancing communication, (iii) reducing disputes and claims, and (iv) preventing fraud. Finally, El Khatib et al. (2021) conclude based on a case study analysis that thanks to its secure, auditable, and transparent way of recording and transferring data, blockchain can help to improve (i) cost management, (ii) processes automation, (iii) transparency, and (iv) stakeholder communications in project management. In summary, the most claimed potentials of blockchain are the creation of trust and transparency within a wider system of social actors, as all the other stated benefits are somewhat side effects of these two key benefits.

However, most of the literature on blockchain in project management is still very conceptual or technical and therefore the propagated benefits of enhancing trust, transparency, efficiency, and communication just theoretical. There is a pronounced lack of research focusing on blockchain-based decentralized applications (dApps) in real-world project management use cases. In particular, the research community has not produced any work about the role of DAOs as a specific category of dApps in project management.

With our study we would like to contribute to this knowledge gap by analyzing how the existing project management methodology could be reinforced and influenced by a blockchain-supported system and bring new insights into one of the main research gaps in project management and blockchain: the role and impact of blockchain technology in the management of real-world projects.

4. Methodology

4.1. Research design

Based on the theoretical lens introduced above, we conduct an exploratory study (see: Saunders et al., 2009) to assess a new phenomenon and to find new insights by answering a specific research question on how blockchain technology affects traditional project management. This initial study can thereby provide the foundation for future theory-building (Easterby-Smith et al., 2015. To produce initial evidence on the implications of blockchain technology for the classic project management principles, this paper uses an experimental setting guided by an Action Design Research (ADR) approach (Sein et al., 2011). By this, we link the theory with practical results to examine the key opportunities and challenges that blockchain technology presents for project management.

4.2. Research method

ADR is according to Sein et al. (2011) a design research method that simultaneously aims to build innovative IT artifacts in an applied context and to learn from the intervention by addressing a problematic situation. Following ADR, the research process was divided into four methodological stages of (i) problem formulation, (ii) building, intervention, and evaluation, (iii) reflection and learning, and (iv) formalization of learning.

4.2.1. Stage I: Problem formulation

We conducted a literature review (Vom Brocke et al., 2015) using a keyword search on EBSCO, ScienceDirect, Scopus, Web of Science, and Google Scholar and applied forward and backward searches to expand the number of articles. We searched mainly within three combinations: by *Project Management Principles* we were able to identify the most important project management principles referred to in the literature. By *Blockchain & DAOs,* we got an overview of the state of the art of the combination of these technologies, as well as some guidelines for the design of the DAPO. Eventually, the combination of the two fields *Project Management & Blockchain* revealed the potential of blockchain applications for project management and exposed gaps in current research.

4.2.2. Stage II: Building, intervention, and evaluation

To determine the impact of organizational change through the use of the DAO, we used certain project management principles as change indicators. Based on the literature review from stage I, we identified several sets of traditional project management principles. We did not start from the possible shortcomings of existing principles but rather focus on their usefulness or adaptability in the different environments of a DAPO. That is the reason to select an "average set" of principles. Therefore, we identified in the first step four well-established traditional project management principle sets. These sets were our base for identifying in the second step a condensed set of "basic principles" that could then be used to measure the effects of the DAPO on traditional project management. To explore the influence of blockchain technology on traditional project management, we looked at a specific application in this field: a decentralized autonomous organization (DAO). For that purpose, we designed and implemented a DAO for project management (a Decentralized Autonomous Project Organization, or DAPO) on the test network of the Ethereum blockchain. Ethereum is an open, permissionless blockchain that provides a decentralized infrastructure for DAOs.[4] This DAPO's purpose consisted of organizing projects and providing a new form of decentralized project management. For the design, we used the features of DAOs identified in the literature review in Stage I to define the traits of the DAPO. For the implementation, we followed the general best practices for blockchain applications.

To evaluate the DAPO, an experiment with 31 students at a University of Applied Sciences in an elective module was conducted. The participants were between 20 and 30 years old and had already some experience with project management. The main purpose of the DAPO was to manage the collaborative innovation of a new business concept for a blockchain startup. In this sense the DAPO organizes an innovation project, in which new ideas are continuously developed, evaluated, selected, prioritized, and implemented (Tidd and Bessant, 2020) – and this in a decentralized way, as no central authority is evaluating,

[4] To learn more about Ethereum, the authors recommend the book "Mastering Ethereum" by A. M. Antonopoulos & G. Wood that is freely available online: https://github.com/ethereumbook/ethereumbook.

selecting, and prioritizing the developed ideas but rather the students themselves. The students were therefore assigned the task of coming up with a business concept for a blockchain startup over the period from October 11, 2021, to December 20, 2021. The project was divided into five consecutive work packages: 1) idea, 2) business plan, 3) token design, 4) go-to-market strategy, and 5) smart contract code. Each of these work packages had a deliverable that the students needed to hand in to the DAPO. They were free in the formation of project teams and could switch groups between the five work packages. As known from the dynamic decision-making process in managing innovation projects (Kock and Georg Gemünden, 2016) the participants voted after each work package on the best submission, selecting the winning concept that served as a basis for the subsequent innovation phase and work package. The goals of this experiment were to observe how the participants would cope with a blockchain-based DAO that takes over the project management, how such a setting affects the deliverables, and whether a DAPO enables self-organization. This experiment also allowed us to study the implications of such an approach on traditional project management principles.

4.2.3. Stage III: reflection and learning

The evaluation of the experiment was multi-faceted. We observed the experiment closely, and this gave us direct insights into the participants' behavior (Baker, 2006). We designed and conducted a survey (Beatty et al., 2019) *ex-ante* and *ex-post* to study whether the participants perceived the project management principles differently. The survey had 18 questions and was conducted on October 11, 2021 (before the experiment started) and again on December 22, 2021 (after the experiment). In the surveys, the participants had to assess the importance of the nine principles on a 5-point Likert scale. We used the Wilcoxon-signed rank test to check for significant changes in the importance score (before vs. after the experiment). Additionally, on November 11, 2021, we assessed the DAPO with the participants in a focus group discussion (Liamputtong, 2011), which we used to collect further impressions from the participants. The participants were asked to discuss the fairness of the DAPO, the ways how they collaborated among each other, their decision-making approaches, their perception of the process, and improvement suggestions.

4.2.4. Stage IV: formalization of learning

We generalized the findings of the DAPO from a DAO-specific setting to a general one for blockchain technology supporting traditional project management. By this, we show how blockchain technology might affect traditional project management. In the paper, the effects on the principles of traditional blockchain technology are discussed in light of a general setup.

5. Designing a Decentralized Autonomous Project Organization

5.1. Features of a decentralized autonomous organization

With the establishment of smart contracts based on blockchain, the emergence of decentralized autonomous organizations (DAO) was only a matter of time. The basic idea behind DAOs is that the assets and governance of an entire organization are encoded in smart contracts and deployed on a public blockchain (Buterin, 2013). For some this also implies that DAOs "run without any human involvement" (Larimer, 2013); however, most authors still agree that DAOs depend on the (voluntary) interaction and participation of people (e.g., El Faqir et al., 2020; Hassan and De Filippi, 2021). For Hsieh and Vergne (2017) "internal stakeholders" are needed to operate, manage, and evolve the DAO through a democratic consultation process. Also, Faqir-Rhazoui et al. (2021) highlight that the governance of DAOs relies on some form of voting by the DAO members and incentives are needed to keep its members aligned with the DAO's overall objectives (Spychiger et al., 2022). Braun and Häusle (2022) further emphasize that the members remain anonymous and can join and leave the DAO at will, without requiring permission. However, it is the governance of DAOs that has given rise to the most debate and concern in the literature. Atzori (2015), for example, highlights the need for central authorities to coordinate in society as a prerequisite for democratic governance. The analysis by Rikken et al. (2019) leads to the further conclusion that due to the lack of clear responsibilities and accountabilities within a network of anonymous participants, the swift decision-making and execution of governance can lead to significant problems. Particularly in crisis situations, it is often observed that decisions done purely on the blockchain infrastructure, and its encoded rules (smart contracts) soon give way to decisions made "off the chain" through more traditional communication channels and between a limited number of stakeholders (see, for example, the DAO Hack (DuPont, 2017). Reijers et al. (2021) therefore distinguish between the on-chain and off-chain governance of DAOs. A similar conclusion is also found in Ziolkowski et al. (2020), which analyses a study of three popular DAOs (Aragon, Tezos, and DFINITY). They found that the three DAOs rely heavily in their development on central actors acting as gatekeepers, fund administrator, or specific knowledge holders, and concluded that rather than a set of autonomous and encoded rules (smart contracts), DAOs are "socio-technical ecosystems consisting of mutually dependent parties".

What exactly constitutes a DAO and what the governance of such DAOs looks like has not yet been defined and needs further research. Nevertheless, we can summarize some specific DAO features based on the literature discussed thus far:

5.1.1. Smart contract

At least some governance aspects (e.g., decision-making, contract executions) of the DAO should be encoded and autonomously executed if triggered (*on-chain* governance).

5.1.2. Public/Permissionless Blockchain

To benefit from the six blockchain properties listed above, a DAO needs to be based on public and permissionless blockchain.

5.1.3. People interaction

A DAO needs to coordinate some sort of human interaction in a decentralized and autonomous manner. This implies that human interaction should be based on smart contracts on a public blockchain.

5.1.4. Democratic consultation/voting Process

A democratic consultation and/or voting process based on smart contracts on a public blockchain is part of the DAO.

5.1.5. Anonymity

Participation on the DAO and its process of the DAO should be completely anonymous. There is no need to provide a specific real-world identity to participate.

5.1.6. Fluent membership

There is no need to apply for participating and/or leaving the DAO. If someone is complying with the encoded rules (e.g., holder of a specific token, staking of tokens, etc.), participation is granted autonomously by the smart contracts of the DAO.

5.1.7. Incentives

In a system without a central authority, incentives keep the members of a DAO aligned and provide some steering mechanisms. They may reward actions that contribute to the objectives of the DAO and are often implemented through coins.

5.1.8. Socio-technical system

As DAOs are still socio-technical systems and in a complex interaction with the outside world, some form of transparent, publicly open and decentralized off-chain governance mechanism will be needed.

5.2. Design choices

In the following, we briefly outline the specific characteristics of the DAPO based on the framework of the eight DAO features and give some explanation for the specific design choices we made.

5.2.1. Public/permissionless blockchain

We opted for the Ethereum network, since it is very well documented and provides a rich set of tools for development. While an implementation on the *mainnet* would not have been feasible due to the high fees, the Ropsten testnet offers the same functionalities without any fees. Ropsten lacks the security of the mainnet, but we did not need this security for our research purposes.

5.2.2. Smart contract

For the technical setup of the DAPO, we implemented two smart contracts in Solidity: ProjectGenerator.sol and TaskGenerator.sol. The first smart contract allows anyone to set up a project, define the workers involved, and become the project sponsor. The second smart contract allows the project sponsor to define all the tasks and the deliverables for the project fulfilment. It also incorporates the logic for all the management of the project, e.g., the deadlines, the voting process, and the rewards.

5.2.3. People interaction

The workers (in this case single students and student-teams) used a webpage interface, which allowed for easy interaction with the smart contracts. Furthermore, Metamask and the web3.js package were required for creating this interface between the webpage and the DAPO. For the interaction, the students used a simple form to upload documents and cast votes on submissions made by others.

5.2.4. Democratic process

Within the DAPO, the workers could state their opinion on the submission created by other groups/individuals. This voting process allowed access to the collective wisdom to identify the most promising submission made to a project. Not yet included was the option to make own proposals from the worker's side (like e.g., stockholder's governance, see Darabseh and Poças Martins, 2022).

5.2.5. Anonymity

The workers needed to open an account on the Ropsten testnet and provided this address to the DAPO. Once registered, they were allowed to submit and participate in the decisions. Their participation was almost anonymous, as only their public address appeared on the blockchain when they conducted a transaction. However, the real identities were known to the project sponsor.

5.2.6. Fluent membership

In a true DAO, members are free to join and leave at any time. However, in the DAPO, this was limited and reflected the framework conditions of a student class or even a company with binding employment contracts. So, it was up to the project sponsors to designate team members, here called workers.

5.2.7. Incentives

There were some coins as incentives to align the interests of all participants, e.g., the workers were rewarded if they voted on a submission or if they voted for the majority. However, they currently had no possibility to change this incentive scheme by any means. Although such governance mechanisms are critical to the development of a DAO over time (Braun and Häusle, 2022), in the interest of simplicity we have not included elaborate governance mechanisms in the DAPO.

5.2.8. Socio-technical system

The website of the DAPO clearly stated the rules and all information on the DAPO in a transparent way. Furthermore, how the coins from the DAPO would be translated to real-world assets (e.g., grades, in the case of students) was also clearly defined. Additionally, to form teams and work together the workers needed to collaborate and communicate with each other outside the DAPO. Therefore, there was still room for a lot of off-chain activities between the workers that needed to be performed based on their social capabilities and within their social network.

5.3. The Decentralized Autonomous Project Organization

Based on the design choices introduced in the foregoing, the DAPO was implemented on the Ethereum testnet. Fig. 1 shows the interaction of the project sponsor and the workers with the DAPO.

The project sponsor initiated a project by providing the project definitions to the DAPO. This encompassed the project name, the project description, the tasks, the task description, and the timeline. The current design of the DAPO allowed only for straightforward waterfall projects that consist of five tasks, each depending on the outcome of previous tasks. However, this was enough to study the initial implications for the principles of project management. Furthermore, the project sponsor also assigned workers to the project. Once this initial setup was completed, the project started within the pre-defined timeframe. Each task had thereby a fixed start and end date, whereby the workers could upload their task contribution and vote on the contributions of the other works. Fig. 2 shows this general process steps and flow for each task. The workers could contribute to a task within the project either as individuals or in a group. They could upload their submission to the DAPO within a pre-defined time window. After the submission phase had passed, the workers would have time to vote on the best submission for the current task. When the voting was closed, the submission with the most votes would be the basis for the next task. The DAPO issued coins to workers to reward them for contributing to the project. These incentives were intended to align workers' actions so that the project could benefit.

The DAPO incentivizes the following actions:

- Uploading a submission
- Voting on a submission
- Voting for the winner
- Receiving votes
- Winning the vote for the submission

While the first two actions incentivize simple participation in the project, i.e., you receive some coins if you work on a task and if you participate in the democratic voting process, the last three actions target different objectives. Rewarding votes for the winning submission incentivizes participants to think about what the majority will perceive as the best submission. The intention was, therefore, to get participants thinking objectively about what the others will perceive as the best submission and vote accordingly. Theoretically, this mechanism should select the best submission for a task and incentivizing the reception of votes and the winning of the voting process should increase the general

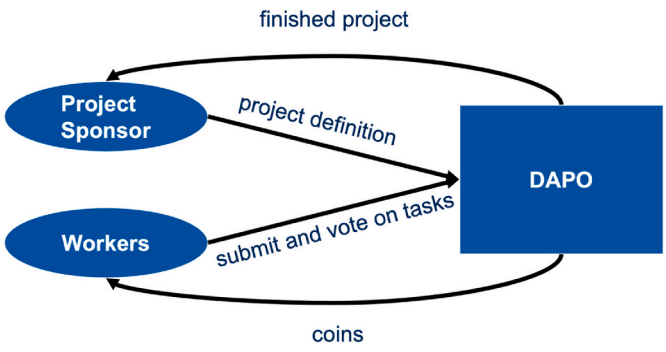


Fig. 1. Interaction of the DAPO with its Environment.

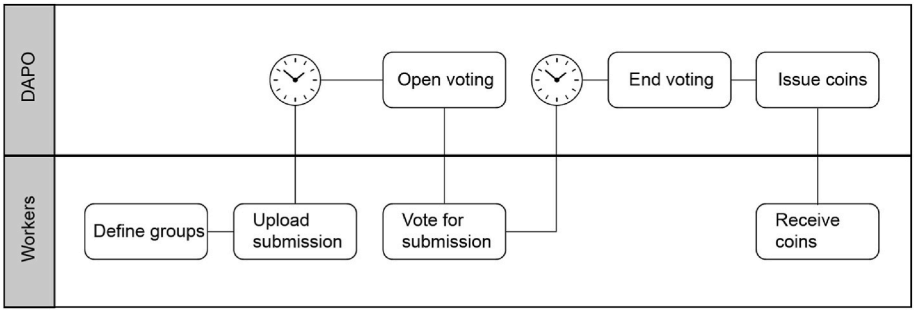


Fig. 2. Process steps and flow for each project task in the DAPO.

quality. While the participants may collect some coins by providing a submission, they stand to gain even more coins with a high-quality submission.

5.4. Experimental Instantiation

For the experiment, we instantiated a version of the DAPO with the following parameters:

Rewarding scheme:

- Uploading a submission 5 coins
- Voting on a submission 3 coins
- Voting for the winner 2 coins
- Receiving votes 1 coin per vote
- Winning the vote for the submission 5 coins

Furthermore, the following rules were added:

- The workers can only submit one immutable submission per task.
- The same submission cannot be submitted twice for a task.
- The maximal group size is six.
- The voting is open for 1 day.
- A worker has only one vote per task.
- A worker cannot vote for his own submission.
- If some submissions receive the same number of votes, the winner is the one that was submitted first.

In the experiment, we measured project management performance. The project consisted, as presented in Table 2, of five tasks with the goal of creating a concept for a blockchain startup. The project was therefore a business development project. Each task had a starting date, an encoded deadline, and a clearly defined expected deliverable. In Task 1, the goal was to come up with an innovative idea for a blockchain startup and to screen the market for similar ideas. Also, the workers needed to explain why their idea was different. In Task 2, they needed to create a business plan explaining the strategy, the customers, and the financials of the startup. In Task 3, the token design tied to the business case had to be elaborated based on what kind of token the startup would use, its supply, and its usage. In Task 4, the workers developed a go-to-market strategy to explain which markets the startup would enter and how. Ultimately, in Task 5, a part of the idea had to be technically implemented by coding smart contracts.

Table 2
Setup of the five Tasks in the DAPO.

Task	Name	Deliverable	Start	Deadline
1	Basic idea + Market Analysis	Pdf (max. 2 p)	10.11.21	16.11.21 20:00
2	Business plan	Pdf (max. 2 p)	17.11.21	23.11.21 20:00
3	Token design	Pdf (max. 2 p)	24.11.21	30.11.21 20:00
4	Go-to-market strategy	Pdf (max. 2 p)	01.12.21	07.12.21 20:00
5	Smart contract code	Pdf	08.12.21	19.12.21 20:00

6. Findings

6.1. Experimental outcome

The students who participated in the experiment submitted a total of 56 submissions. While for the first task, they handed in 12 project ideas, for the subsequent tasks there were in all cases 11 submissions. Almost all students participated in the voting process every time. Overall, the DAPO issued and distributed 1916 coins to the students. The highest coin score was 84, whereas the lowest was 31. Additionally, we observed that the thirteen students who received the most coins won at least one task, whereas the six that received the fewest coins all missed at least one submission.

The DAPO was able to manage and coordinate the whole project by itself, without any intervention from the lecturer. The students self-organized themselves in groups, decided individually on the submission (by voting), and built every subsequent task on top of the previous one. This means that the DAPO allowed for a dynamic path in the project that led to a high-quality product. While not all submissions were of high quality, the submission with the most votes in every task was always of high quality. Thus, in the end, the DAPO was able to organize, govern, and manage the project in a very decentralized fashion fostering a high degree of self-organization, with nonetheless a qualitatively good deliverable for every task. Furthermore, the concept of a blockchain startup that emerged was very satisfying to the lecturer (project sponsor).

6.2. Evaluation

6.2.1. Survey results

The results of the ex-ante and ex-post surveys with respect to the importance of each of the nine principles produced several observations: **First**, as presented in Fig. 3, while the students attributed principle P5 (*The project goal must be clearly defined)* the highest average perceived importance before the experiment (4.62) the average perceived importance of P4 (*There must be a dedicated team)* was ranked first, with (4.40), after the experiment. The importance of both principles changed (P5 decreased, P4 increased) significantly at the 5% significance level (Wilcoxon-signed rank test). **Second**, besides P4 and P5, only two further principles out of the nine saw a significant change as well, both by increasing their perceived importance: these were P3 (*There must be supportive management*) and P9 (*The organization fosters a culture of transparency and trust*). **Third**, the three principles with a significant increase in importance for the students after the experiment with the DAPO (P3, P4, P9) can be classified along with P2 (*There must be a single leader*) as more "social aspects-related" principles in comparison to the other five principles (P1, P5, P6, P7, P8), which are mainly "project

Table 3
Four Sets of traditional Project Management Principles.

SET	A	B	C	D
	PRINCE2	Bing, J.	Queensland Government - Department of Transport and Main Roads	Governance of Project Management Principles (APM)
Link	https://www.prince2.com/de/blog/the-7-principles-themes-and-processes-of-prince2	https://www.pmi.org/learning/library/pm-project-management-principles-3400	https://www.tmr.qld.gov.au/business-industry/OnQ-Project-Management-Framework/OnQ-project-governance/Principles	https://www.apm.org.uk/media/26444/directing-change-sample-chapter.pdf
Principles	A1. Continued Business Justification	B1. There must be a project as defined in the PMBOK, and not just a task or an ongoing activity.	C1. Both customer and team must be committed to the project	D1. The board has overall responsibility for governance of projects.
	A2. Learn from Experience	B2. There must be a single leader (project manager), one who is experienced and willing to take responsibility for the work.	C2. Measures of success must be pre determined	D2. The roles, responsibilities and performance criteria for the governance of project management are clearly defined.
	A3. Define Roles and Responsibilities	B3. There must be an informed and supportive management that delegates appropriate authority to the project manager.	C3. Planning — first plan, then do	D3. Disciplined governance arrangements, supported by appropriate methods and controls, are applied throughout the project life cycle.
	A4. Manage by Stages	B4. There must be a dedicated team of qualified people to do the work of the project.	C4. Single point of responsibility	D4. A coherent and supportive relationship is demonstrated between the overall business strategy and the project portfolio.
	A5. Manage by Exception	B5. The project goal must be clearly defined along with the priorities of the "shareholders."	C5. Procedures must be established before work commences	C5. All projects have an approved plan containing authorisation points at which the business case is reviewed and approved. Decisions made at authorisation points are recorded and communicated.
	A6. Focus on Products	B6. There must be an integrated plan that outlines the action required in order to reach the goal.	C6. Trade-off — scope, time, cost and quality must be mutually consistent and attainable	D6. Members of delegated authorisation bodies have sufficient representation, competence, authority and resources to enable them to make appropriate decisions.
	A7. Tailor to the Environment	B7. There must be a schedule establishing the time goals of the project. B8. There must be a budget of costs and/or resources required for the project.	C7. Management must provide an informed and supportive environment	D7. The project business case is supported by relevant and realistic information that provides a reliable basis for making authorisation decisions. D8. The board or its delegated agents decide when independent scrutiny of projects and project management systems is required, and implement such scrutiny accordingly. D9. There are clearly defined criteria for reporting project status and for the escalation of risks and issues to the levels required by the organisation. D10. The organisation fosters a culture of improvement and of frank internal disclosure of project information. D11. Project stakeholders are engaged at a level that is commensurate with their importance to the organisation and in a manner that fosters trust.

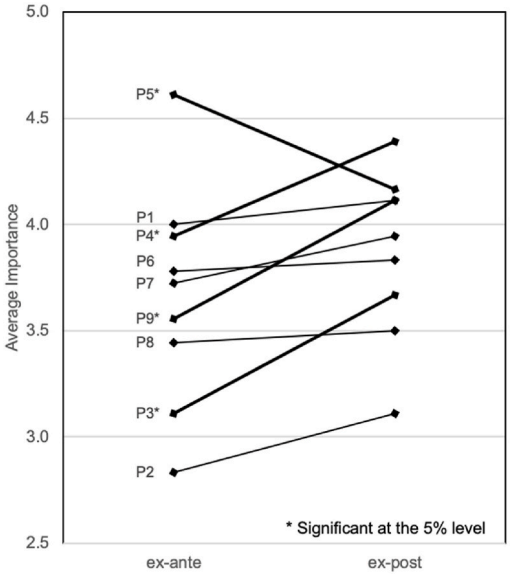
structure-related" principles.

6.2.2. Focus group

Half of the participants perceived the DAPO as fair, while the other half perceived the DAPO as unfair. The participants who argued that the DAPO is fair emphasized the democratic process, the anonymity, and that high-quality work was generally recognized in the voting process. The participants who felt unfairly treated criticized the winner-takes-it-all approach, possible collusion (even though there was no evidence that this was happening), and that the voters have been persuaded by aspects other than the content, e.g., the design of the submission. In response to questions on how the participants decided in the voting process, 92% answered that they had opened and (at least partially) read the submissions, 8% decided by only looking at the title, and nobody decided randomly. Additionally, 12% found working with the DAPO very motivating, for 24% it was frustrating, and for the majority (64%), it was neither positive nor negative. Also, only 2 students changed groups over the course of the five tasks, the rest of the teams kept their constellation over the course of the project. In general, some of the participants very much liked the concept, while others suggested improvements. The group suggested adaptions of the incentive system. The participants proposed schemes that distribute coins according to the rank of the submissions instead of only rewarding the winner. Furthermore, a customized submission format should be provided to avoid that the design rather than the content wins votes. Also, possibilities to build on own ideas should be given in the DAPO such that multiple projects can be pursued.

7. Discussion

As a result, the entire, admittedly still simple, project was managed during its execution without any central intervention. The students (project team members, aka workers) organized and managed themselves over the DAPO very much in an autonomous way. In line with the literature (e.g., El Faqir et al., 2020; Hassan and De Filippi, 2021), the DAPO took over the role of a "central" decision-making authority, whereby the main structural project management decisions were encoded before the start of the project (e.g., objectives, task description, deadlines, incentives, voting procedures, payouts, etc.). Also, in accordance with the literature, other decisions were made during the project by the workers themselves based on a democratic voting system and their social abilities to organize themselves within their group and social network. The sponsor had an automatically updated ongoing overview and control. Therefore, from a feasibility standpoint, the experiment was



Question Number	ex-ante	ex-post
P1	4.000	4.111
P2	2.833	3.111
P3*	3.111	3.667
P4*	3.944	4.389
P5*	4.611	4.167
P6	3.778	3.833
P7	3.722	3.944
P8	3.444	3.500
P9*	3.556	4.111

P1: The project must be clearly defined
P2: There must be a single leader
P3: There must be a supportive management
P4: There must be a dedicated team
P5: The project goal must be clearly defined
P6: There must be an integrated plan
P7: There must be a schedule
P8: There must be a budget
P9: The organization fosters a culture of transparency and trust

Fig. 3. Results of ex-ante and ex-post surveys.

a great success because it showed that blockchain-based DAO features derived from the literature allowed us to establish a functional Decentralized Autonomous Project Organization. This DAPO could manage a project very efficiently by automating and minimizing the overhead for project management. Also, the technical features of the DAPO that were implemented worked very well during the experiment, without any need for technical intervention. All tasks were completed, and the students contributed their work at a good level of quality. As this was an experimental setting, the complexity of the project was relatively low and the interaction with stakeholders was very limited. Nevertheless, we were able to identify some trends and gain some interesting insights regarding the impact of a DAPO on the principles of traditional project management.

7.1. Growing importance of off-chain teamwork

From the outset of the project, it is remarkable that the students gave the lowest average importance score of all principles both at the beginning and at the end of the experiment (2.8 and 3.1, respectively) to the principle 2 '*There must be a single leader*'. This could imply that the students were already very much used to working in groups and did not really believe that there is a need for a "single responsible leader" to be successful in projects. To them, teamwork seems much more important than trust in a single leader. This view is supported by the high importance of P4 '*There must be a dedicated team*', which even significantly increased during the project. This increase in the importance (from 3.9 to 4.4) of a dedicated team to successfully deliver a project can be explained by the fact that most of the "real" project work was still done in a traditional, off-chain environment in interaction with the social network. This implies that in line with the literature about DAOs (e.g., El Faqir et al., 2020; Hassan and De Filippi, 2021) the qualification and the social abilities of each team member as well as a clear off-chain definition of each role were still very important aspects within the DAPO. Especially since registration and voting of the individual work were very much code-based and automated, there was also no room for failure or excuses (like a task being delivered late). Furthermore, as the team composition was not fixed, each student also knew from the beginning that he/she could be excluded from the team at any time in case his/her performance was not good enough. This could have given the students an even greater dedication to the team and less opportunity for "free riders". In any case, the freedom of work distribution within the tasks is greatly increased, which has been found to be important for future of work in project teams (Hanif, 2011) We could therefore speculate that by implementing blockchain-based project management the importance of teamwork even grows.

7.2. Novelty needs support

In a DAPO environment, the management of the project seems to be divided into two parts: one with a strong structure with specifications and processes, and another with greater demands on self-organization. Based on the literature (e.g., El Faqir et al., 2020; Hassan and De Filippi, 2021), one could expect in this situation lower importance to be placed on management support due to the self-organization aspect. However, our results demonstrated the opposite by increasing importance of P3 '*There must be supportive management*' (from 3.1 to 3.7), and it seems that the novelty of the process demands more support from the management. This has aspects of collaborative leadership style in agile project management (Salameh, 2014) but also shows new aspects. For example, it became apparent that owing to the automation of the DAPO, workers need to be familiar with the new decentralized approach and the pre-coded rules (e.g., no late hand-in possible), as otherwise, some potential for frustration arises. As only 12% of the participants found the DAPO motivating, there might be some additional factors relevant to the students that are not reflected in the current DAPO setting and that need additional support. In particular, a winner-takes-it-all scheme seemed to be demotivating, as the participants could not follow up their own ideas. There are certainly potential improvements in the parametrization of the DAPO, especially in the incentive system which was not received well by all students.

7.3. DAPO overtakes structure and procedures

In this experiment, the project sponsor predefined the five project tasks, the expected content of each task, and the procedural structure of the project. However, the "measures of success" were defined at the end by the votes of the project team members (students) as internal stakeholders on the uploaded reports. From this perspective, it makes sense that within this DAPO design for the students the fifth principle "the project goal must be clearly defined" would seem less important because they could influence the product's outcome and measures of success. In fact, in our experiment, this fifth principle was the only one that significantly lost importance for the students (from 4.61 to 4.17), although its importance was still rated relatively high. Furthermore, by

looking at the other more structural and procedural project management principles P6 (integrated plan), P7 (schedule), and P8 (budget), we could see that all of them are not highly ranked from the outset of the project and did not gain any more importance for the students. As stated in the description of the experiment, the DAPO itself was very strongly fixed in terms of time constraints. If we take the triple constraint of time, scope, and cost, the experiment did compromise on the scope, as the quality was only measured relatively (by voting). However, as the experiment showed, the DAPO could deliver a high-level project result, which again would support the traditional principle that successful projects need to have an integrated plan and a clear schedule. Additionally, in our experiment there was no project budget as such; only the cost of the incentive system was measured in a kind of money (tokens). However, the number of tokens issued and distributed over the project span was very much fixed and could be budgeted from the beginning which would be in line with an agile approach. P8 could be well implemented in a DAPO, as it is up to the project sponsor to define the amount (and therefore value) of the issued tokens throughout the project. By directly coupling operations with token disbursement, a DAPO shows promise for monitoring budget utilization directly with work package fulfillment. That would point to other and perhaps simpler ways for the process-mapping and prioritizing compared to those used by established project management methodologies such as PMI (2017, 2021), IPMA (2018), Prince2 (2022a, b), or corresponding software development approaches (Barbosa, 2022).

As mentioned already in the Findings section, we could observe that the principles that gained importance (P3, P4, P9) all focus on social aspects of project management, while the other principles that did not move or decreased in importance for the workers can be classified as structural aspects of project management. It seems that during a project supported by a DAPO, the social aspects are perceived as increasingly more important in comparison to the structural aspects of project management. Obviously, the DAPO copes very well with the more structural and procedural aspects of traditional project management (P1, P5, P6, P7, and P8). It seems that while the DAPO framework explicitly calls for a precise definition of all these structural aspects at the beginning to be implemented directly on a blockchain, these fade into the background and make social aspects appear more important. This would also be an interesting feature in the design of innovative project-oriented organizations (Gemünden et al., 2018).

7.4. Enhanced transparency and trust

The survey revealed that the importance of principle 9 (“the organization fosters a culture of trust and transparency”) increased significantly during the experiment with the DAPO (from 3.6 to 4.1). In our opinion, this increase in importance could be directly attributed to the experience the students had with a decentralized autonomous organization. They were interacting with each other over blockchain-based smart contracts and therefore, all interactions were transparent and independent of any “unjustified” intervention by a superior entity like a project manager or sponsor. In the DAO literature this is revered as a ‘censorship-free’ environment (see: Buterin, 2016). The students had full transparency into the other teams’ performances and could even classify (vote) as a community transparently and directly the best performance. This democratic characteristic of the DAPO was also the most frequently mentioned positive aspect of the experiment. Overall, our concrete implementation confirmed the performance claims of Renwick and Tierney (2020): The DAPO made the whole process transparent (i) and gave more control to the workers (ii). Throughout the project, the status of the project was dynamically updated (iii). The DAPO also gave good incentives (iv) through the issuance of tokens. All of this enhanced the trust (v) in the process as everything was done in a pre-defined and decentralized fashion.

7.5. Potential implications for project managers

Looking at the implications of our findings for practitioners, we can assume that social skills and competencies are becoming more important in project management due to the digitalization. This mainly as new technological innovations like decentralized autonomous organizations are able to take over structure in projects, but not social aspects. Additionally, our results indicate that self-organized teamwork tend to be more important than direct command and control by a single project leader. This further strengthens the aspect that social skills and competencies like motivating team members, sensing team spirit and attitudes, or mediating team conflicts are becoming in the future even more important for successful project managers and team members than today. Selecting the ‘right’ team members at the beginning of a certain project will therefore be a crucial task for any project organizations and stakeholder. The aspect that team members have a say in this crucial project phase and can even select their own team members can be in our opinion a very effective and efficient approach in practice to get the commitment of everyone. In this regard, an open and dynamic team composition is another practical method that can help ensure that all team members are fully engaged in the project team, as free riders can be excluded by the team itself.

Another aspect that became clear is the importance of transparency and trust in fair evaluation and compensation of team as well as individual performance, especially in the light of self-organized teams. In this regard, a blockchain-based DAPO can create an environment where transparency and trust are technically guaranteed. However, it is evident from our study that the definition of "fair" is difficult in practice and cannot be solved technically, but rather must be negotiated beforehand with all stakeholders involved. The results at least suggest that an overly competitive payout system such as winner-take-all is perceived by many as "unfair" in practice and that more balanced compensation and incentive models are needed for projects to succeed.

8. Conclusion

This study addressed the question of how project management supported by blockchain technology might look like and provided some answers in an experimental setting. By implementing a with the DAPO, a blockchain-supported environment for project management and testing it within a student experiment, we showed that such an approach works and brings interesting new mechanisms to the management of simple projects. A DAPO can manage projects to a certain degree and create a base for the dynamic coordination of project teams. Furthermore, it can generate a project outcome of high quality for the project sponsor and takes over many tasks related to the more structural aspects of project management (e.g., objectives, schedule, milestones, rewards, and rules). However, the design and parametrization of such a DAPO are difficult, and not all the students were content with the provided conditions. Because of this first exploration, we can say that a DAPO is a valuable way to support the structural aspects of project management through blockchain technology; nevertheless, the optimal design is still an open question.

Additionally, we got some results for the second research question on how such a new method would affect traditional project management. The study explored some practical implications of blockchain technology on project management, which, to our knowledge, has not yet been done before. Our results demonstrate that mainly social aspects of a project like a dedicated team, supportive management, and an improvement culture become evidently more important in a digitalized, self-organized setting, especially when the structural aspects are encoded and very much fixed from the outset of the project. Furthermore, having clearly defined project goals in a more decentralized and dynamic setting with less stakeholder intervention seems significantly less important, as team members have a higher say. However, other principles regarding the structure were not significantly influenced by the

decentralized setup: budget, schedule, integrated plan, and project definitions. Especially, interesting is the low importance the students gave to the principle of a single responsible leader. Here we see a tendency in the social interactions of young people to not follow a leader but rather participate in projects on an equal footing in a dedicated team. With this, we can answer our second research question and conclude that for blockchain-supported project management, social aspects like team and management factors gain importance, while structural-related aspects like the objective and procedures of projects seem to remain unchanged.

As we have conducted only a single experiment with a limited number of students, the results presented here are not yet very reliable and should only be considered as a starting point for further research on the impact of blockchain technology on project management. One could argue that student projects are always organized without a formal leader and developing a blockchain startup could create a bias, however, the students had to interact with the DAPO through a common webpage interface. Therefore, the process of using the DAPO would be the same for other projects. Nevertheless, it would be interesting to see the DAPO being applied to different contexts. While we showed the value of a DAPO for a simple project, it remains open if a DAPO can also be used in more complex projects. We also did not explore if blockchains violate certain project management principles and leave this for future research. Furthermore, based on our experiment, we see the high inflexibility of the DAPO (and perhaps the blockchain technology itself) as very critical, especially considering more modern and agile project management concepts. It would be therefore interesting to explore the possibilities of including more flexibility in the DAPO, for example by implementing additional voting mechanisms that might allow the work package objectives to be adapted during the project to the changing needs of the stakeholders. This would also be more suitable for complex projects with changing requirements. Also, according to the feedback of the students, the incentive scheme of the DAPO was not perceived as fair, which implies for further experiments that the incentives should be carefully defined/redefined with the objective of increasing the perceived fairness by the workers. Tokens provide a novel way to reward project workers and their implementation and use in real-world projects can be explored. Moreover, future studies should also investigate the overall effect of the DAPO on the motivation of the workers involved in projects. Overall, we believe that the use of a DAPO was a success and was able to provide valuable insights into the impact of blockchain technology on project management.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

References

Amoah, E., Oh, J.-Y.O., 2021. Blockchain adoption in project management. Iss. Inform. Syst. https://doi.org/10.48009/4_iis_2021_152-167.

Armitage, K., 2002. Project management—concept and some basic principles. Manager 34, 10–11.

Association for Project Management (APM), 2018. Directing Change: A Guide to Governance of Project Management, third ed. Association for Project Management, Buckinghamshire.

Atzori, M., 2015. *Blockchain Technology and decentralized governance: Is the state still necessary?* (SSRN scholarly paper No. 2709713). Soc.Sci. Res. Network. https://doi.org/10.2139/ssrn.2709713.

Baker, L., 2006. Observation: a complex research method. Libr. Trends 55 (1), 171–189. https://doi.org/10.1353/lib.2006.0045.

Barbosa, X.D.R., 2022. Integrated and Decentralized Project Management (Doctoral Dissertation). Instituto Politécnico do Porto. http://hdl.handle.net/10400.22/22688.

Baum, A., 2021. Tokenization—the future of real estate investment? J. Portfolio Manag. 47 (10), 41–61. https://doi.org/10.3905/jpm.2021.1.260.

Beatty, P.C., Collins, D., Kaye, L., Padilla, J.-L., Willis, G.B., Wilmot, A., 2019. Advances in Questionnaire Design, Development, Evaluation and Testing. John Wiley & Sons.

Beedle, M., van Bennekum, A., Cockburn, A., et al., 2001. *Manifesto for Agile Software Development*. Agile Alliance. Retrieved April 14, 2022, from. https://agilemanifesto.org/.

Bekker, M.C., Steyn, H., 2008. The impact of project governance principles on project performance. PICMET '08 – 2008 Portland Int. Conf. Manag.Eng. Technol. 1324–1330. https://doi.org/10.1109/PICMET.2008.4599744.

Bing, J.A., 1994. Principles of Project Management | PMI. Retrieved April 13, 2022, from. https://www.pmi.org/learning/library/pm-project-management-principles-3400.

Braun, A., Häusle, N., 2022. Collusion-proof decentralized autonomous organizations. SSRN Electron. J. https://doi.org/10.2139/ssrn.3760531.

Buterin, V., 2013. *Ethereum Whitepaper*. Ethereum.Org. Retrieved April 14, 2022, from. https://ethereum.org.

Buterin, V., 2016. *Ethereum*. Coin Center. https://www.coincenter.org/education/key-concepts/ethereum/.

Cleland, D.I., King, W.R., 1986. Systems Analysis and Project Management. McGraw-Hill, New York.

Darabseh, M., Poças Martins, J., 2022. Construction DAO for improved project management and stakeholder's engagement. In: Conference Paper: 4° Congresso Português De Building Information Modelling at: Braga, Portugal. https://hdl.handle.net/10216/140931.

Das, S.K., Pandey, D., Dey, B., Dasgupta, S., Saha, S., 2019. *Project management system using blockchain Ethereum platform* (SSRN scholarly paper No. 3503505). Soc.Sci. Res. Network. https://doi.org/10.2139/ssrn.3503505.

Das, M., Tao, X., Liu, Y., Cheng, J.C., 2022. A blockchain-based integrated document management framework for construction applications. Autom. ConStruct. 133, 104001 https://doi.org/10.1016/j.autcon.2021.104001.

DuPont, Q., 2017. Experiments in algorithmic governance: a history and ethnography of "The DAO," a failed decentralized autonomous organization. In: Bitcoin and beyond. Routledge.

Easterby-Smith, M., Thorpe, R., Jackson, P.R., 2015. Management and Business Research, fifth ed. SAGE Publications Ltd.

El Faqir, Y., Arroyo, J., Hassan, S., 2020. An overview of decentralized autonomous organizations on the blockchain. Proc.16th Int.Sympos. Open Collaborat. 1–8. https://doi.org/10.1145/3412569.3412579.

El Khatib, M., Beshwari, F., Beshwari, M., Beshwari, A., 2021. The impact of blockchain on project management. ICIC Express Lett. 15 (5), 467–474.

Faqir-Rhazoui, Y., Arroyo, J., Hassan, S., 2021. A comparative analysis of the platforms for decentralized autonomous organizations in the Ethereum blockchain. J. Internet Serv. Appl. 12 (1), 9. https://doi.org/10.1186/s13174-021-00139-6.

Gemünden, H.-G., Lehner, P., Kock, A., 2018. The project-oriented organization and its contribution to innovation. Int. J. Proj. Manag. 36 (1), 147–160. https://doi.org/10.1016/j.ijproman.2017.07.009.

Gubinelli, S., Cesarotti, V., Introna, V., 2022. The evolution of project management (PM): how agile, lean and six Sigma are changing PM. J. Mod. Project Manag. 7 (3). Retrieved from. https://journalmodernpm.com/manuscript/index.php/jmpm/article/view/JMPM02108.

Hanif, T., 2011. A new approach to Project Management based on a combination of Predictive and Adaptive thinking. In: Thesis Submitted to the Faculty of Science, Engineering and Computing. Kingston University London. https://eprints.kingston.ac.uk/id/eprint/22968/.

Hargaden, V., Papakostas, N., Newell, A., Khavia, A., Scanlon, A., 2019. The role of blockchain technologies in construction engineering project management. In: 2019 *IEEE International Conference on Engineering, Technology and Innovation*. ICE/ITMC, pp. 1–6. https://doi.org/10.1109/ICE.2019.8792582.

Hassan, S., De Filippi, P., 2021. Decentralized autonomous organization. Internet Pol. Rev. 10 (2), 1–10. https://doi.org/10.14763/2021.2.1556.

Hewavitharana, T., Nanayakkara, S., Perera, S., 2019. Blockchain as a project management platform. In: Proceedings of the 8th World Construction Symposium. 8th World Construction Symposium, Colombo, Sri Lanka. https://doi.org/10.31705/WCS.2019.14.

Hoda, R., Murugesan, L.K., 2016. Multi-level agile project management challenges: a self-organizing team perspective. J. Syst. Software 117, 245–257. https://doi.org/10.1016/j.jss.2016.02.049, 2016.

Hsieh, Y.-Y., Vergne, J.-P., 2017. Bitcoin and the rise of decentralized autonomous organizations (SSRN scholarly paper No. 3082911). Soc.Sci. Res. Network. https://papers.ssrn.com/abstract=3082911.

Iansiti, M., Lakhani, K.R., 2017. The Truth about Blockchain. *Harvard Business Review*. https://hbr.org/2017/01/the-truth-about-blockchain.

International Project Management Association (IPMA), 2018. Standard—ICB4. Retrieved April 13, 2022, from. https://www.ipma.world/individuals/standard/.

Kelly, E., 2010. Governance Rules! the Principles of Effective Project Governance. PMI Global Congress, Washington, DC, 2010. https://www.pmi.org/learning/library/project-governance-principles-corporate-perspective-6528.

Kock, A., Georg Gemünden, H., 2016. Antecedents to decision-making quality and agility in innovation portfolio management. J. Prod. Innovat. Manag. 33 (6), 670–686. https://doi.org/10.1111/jpim.12336.

Konashevych, O., 2020. General concept of real estate tokenization on blockchain: the right to choose. Eur. Property Law J. 9 (1), 21–66. https://doi.org/10.1515/eplj-2020-0003.
Larimer, S., 2013. *Bitcoin and the Three Laws of Robotics*. Let's Talk Bitcoin. Retrieved April 13, 2022, from. https://letstalkbitcoin.com/blog/post/bitcoin-and-the-three-laws-of-robotics.
Liamputtong, P., 2011. Focus Group Methodology: Principles and Practice. SAGE Publications Ltd. https://doi.org/10.4135/9781473957657.
Lichtenberg, S., 1989. New project management principles for the conception stage: outline of a new 'generation.'. Int. J. Proj. Manag. 7 (1), 46–51. https://doi.org/10.1016/0263-7863(89)90054-9.
Little, B., 2011. The principles of successful project management: it takes careful planning, skilful leadership and a little bit of luck. Hum. Resour. Manag. Int. Digest 19 (7), 36–39. https://doi.org/10.1108/09670731111175597.
Lotti, L., 2019. The art of tokenization: blockchain affordances and the invention of future milieus. Media Theor. 3 (1), 287–320.
Lu, W., Wu, L., Xue, F., 2022. Blockchain technology for projects: a multicriteria decision matrix. Proj. Manag. J. 53 (1), 84–99. https://doi.org/10.1177/87569728211061780.
Luong, H.H., Huynh, T.K.N., Dao, A.T., Nguyen, H.T., 2021. An approach for project management system based on blockchain. In: Dang, T.K., Küng, J., Chung, T.M., Takizawa, M. (Eds.), Future Data and Security Engineering. Big Data, Security and Privacy, Smart City and Industry 4.0 Applications. Springer, pp. 310–326. https://doi.org/10.1007/978-981-16-8062-5_21.
Lustenberger, M., Malešević, S., Spychiger, F., 2021. Ecosystem readiness: blockchain adoption is driven externally. Front. Blockchain 4, 720454. https://doi.org/10.3389/fbloc.2021.720454.
Marnewick, C., Marnewick, A.L., 2022. Digitalization of project management: opportunities in research and practice. Project Leadership Soc. 3, 100061 https://doi.org/10.1016/j.plas.2022.100061.
Morris, P.W.G., 2012. Cleland and King: project management and the systems approach. Int. J. Manag. Proj. Bus. 5 (4), 634–642. https://doi.org/10.1108/17538371211268951.
Nakamoto, S., 2008. Bitcoin: a peer-to-peer electronic cash system. Retrieved April 14, 2022, from. https://bitcoin.org/bitcoin.pdf.
Ni, Y., Sun, B., Wang, Y., 2021. Blockchain-based BIM digital project management mechanism research. IEEE Access 9, 161342–161351. https://doi.org/10.1109/ACCESS.2021.3130270.
Pastor, I.G., Olaso, J.R.O., Fuente, F.S., 2018. Unveiling the Opportunities of Using Blockchain in Project Management, vol. 92. Research and Education in Project Management.
PRINCE2, 2022a. What is PRINCE2? The Definition. History & Benefits Retrieved Dec. 16, 2022, from. https://www.prince2.com/usa/blog/the-7-principles-themes-and-processes-of-prince2.
PRINCE2, 2022b. The history of PRINCE2? The Definition. History & Benefits Retrieved Dec. 16, 2022, from. https://www.prince2.com/usa/blog/the-history-of-prince2.
Project Management Institute (PMI), 2017. A Guide to the Project Management Body of Knowledge, sixth ed. Project Management Institute.
Project Management Institute (PMI), 2021. A Guide to the Project Management Body of Knowledge, seventh ed. Project Management Institute.
Queensland Department of Transport and Main Roads, 2022. *Project Management Principles*. corporateName=Department of Transport and Main Roads; jurisdiction=Queensland; Sector=government. https://www.tmr.qld.gov.au/Business-and-industry/OnQ-Project-Management-Framework/OnQ-project-governance/Principles.aspx.
Reijers, W., Wuisman, I., Mannan, M., De Filippi, P., Wray, C., Rae-Looi, V., Cubillos Vélez, A., Orgad, L., 2021. Now the code runs itself: on-chain and off-chain governance of blockchain technologies. Topoi 40 (4), 821–831. https://doi.org/10.1007/s11245-018-9626-5.
Renwick, R., Tierney, B., 2020. Are blockchain-based systems the future of project management? A preliminary exploration. J. Brit. Blockchain Associat. 3 https://doi.org/10.31585/jbba-3-2-(2)2020.
Rikken, O., Janssen, M., Kwee, Z., 2019. Governance challenges of blockchain and decentralized autonomous organizations. Inf. Polity 24, 1–21. https://doi.org/10.3233/IP-190154.
Roth, J., Schär, F., Schöpfer, A., 2021. The tokenization of assets: using blockchains for equity crowdfunding. In: Wendt, K. (Ed.), Theories of Change: Change Leadership Tools, Models and Applications for Investing in Sustainable Development. Springer International Publishing, pp. 329–350. https://doi.org/10.1007/978-3-030-52275-9_19.
Rozas, D., Tenorio-Fornés, A., Díaz-Molina, S., Hassan, S., 2021. When ostrom meets blockchain: exploring the potentials of blockchain for commons governance. Sage Open 11 (1), 21582440211002530. https://doi.org/10.1177/21582440211002526.
Salameh, H., 2014. What, when, why, and how? A comparison between agile project management and traditional project management methods. Int.J. Business Manag. Rev. 2 (5), 52–74. https://eajournals.org/ijbmr/vol-2issue5october-2014/comparison-agile-project-management-traditional-project-management-methods/Sankaran,S.
Saunders, M., Lewis, P., Thornhill, A., 2009. Research Methods for Business Students. Pearson Education.
Sein, M.K., Henfridsson, O., Purao, S., Rossi, M., Lindgren, R., 2011. "Action Design Research," MIS Quarterly, pp. 37–56.
Sonmez, R., Sönmez, F.Ö., Ahmadisheykhsarmast, S., 2021. Blockchain in project management: a systematic review of use cases and a design decision framework. J. Ambient Intell. Hum. Comput. https://doi.org/10.1007/s12652-021-03610-1.
Spychiger, F., Lustenberger, M., 2022. Decision-making in blockchains. In: 22nd EURAM Annual Conference.
Spychiger, F., Tessone, C.J., Zavolokina, L., Schwabe, G., 2022. Incentivizing data quality in blockchain-based systems—the case of the digital cardossier. Distrib. Ledger Technol. 1 (1) https://doi.org/10.1145/3538228.
Szabo, N., 1996. Smart contracts: building blocks for digital markets. Extropy J. Transhuman Thought 16. https://www.fon.hum.uva.nl/rob/Courses/InformationInSpeech/CDROM/Literature/LOTwinterschool2006/szabo.best.vwh.net/smart_contracts_2.html.
Tapscott, D., Tapscott, A., 2017. How blockchain will change organizations. MIT Sloan Manag. Rev. 58 (2), 10–13.
The Economist, 2015. The Trust Machine: the Promise of the Blockchain. Retrieved April 14, 2022, from. https://www.economist.com/node/21677198/print.
Thompson, K.M., Williams, N., 2018. A Guide to Responsible Project Management, vol. 2018. Bournemouth University. http://sustainabilitypractitioners.org/wp-content/uploads/2018/12/rpm_web_booklet.pdf.
Tidd, J., Bessant, J.R., 2020. Managing Innovation: Integrating Technological, Market and Organizational Change, seventh ed. John Wiley & Sons.
Vigna, P., Casey, M.J., 2018. The Truth Machine: the Blockchain and the Future of Everything. St. Martin's Publishing Group.
Vom Brocke, J., Simons, A., Riemer, K., Niehaves, B., Plattfaut, R., Cleven, A., 2015. Standing on the shoulders of giants: challenges and recommendations of literature search in information systems research. Commun. Assoc. Inf. Syst. 37 (1) https://doi.org/10.17705/1CAIS.03709.
Walker, D., Lloyd-Walker, B., 2018. The future of the management of projects in the 2030s. Int. J. Manag. Proj. Bus. 12 (2), 242–266. https://doi.org/10.1108/IJMPB-02-2018-0034.
Wideman, M., 2009a. First Principles of Project Management—Part 1. http://www.maxwideman.com/papers/first_principles/first_principles.pdf.
Wideman, M., 2009b. First Principles of Project Management—Part 2. http://www.maxwideman.com/papers/first_principles/first_principles2.pdf.
Winch, G., 2014. Three domains of project organizing. Int. J. Proj. Manag. 32 (5), 721–731. https://doi.org/10.1016/j.ijproman.2013.10.012.
Wu, T., 2022. Digital project management: rapid changes define new working environments. J. Bus. Strat. 43 (5), 323–331. https://doi.org/10.1108/JBS-03-2021-0047.
Ziolkowski, R., Miscione, G., Schwabe, G., 2020. Exploring decentralized autonomous organizations: towards shared interests and 'code is constitution'. In: Forty-First International Conference on Information Systems (ICIS), Virtual (India), 13 - 16 December, Exploring Decentralized Autonomous Organizations https://doi.org/10.5167/uzh-193663.