DOI: 10.18254/S278229070028454-5 Original article

Blockchain for Science, from Covid-19 towards DeSci: the Implementation of Decentralized Technologies in Young Academia

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Abstract: This paper explores the evolving landscape of blockchain technology and its applications in the field of science, with a specific focus on the period from 2021 to 2023. It examines the challenges and opportunities posed by blockchain, particularly in the context of decentralized autonomous organizations (DAOs) and the concept of decentralized science (DeSci).The research draws on a comprehensive review of existing literature, including prior works by the author related to blockchain in science, as well as an analysis of recent developments in the blockchain ecosystem. It discusses the principles of blockchain technology and its potential in academia, addressing both the technical and socio-organizational aspects of its implementation. The paper reveals the shift in focus from blockchain as a tool for transparency and automation in science to its decentralization aspects, such as DAOs. It highlights the application of DAOs in research crowdfunding, decentralized decision-making, and cross-border collaboration, with a special emphasis on the Covid-19 interlude in 2020-2021. The discussion also delves into the role of non-fungible tokens (NFTs) in science, which provide new avenues for monetizing research and democratizing funding and organization in the field.The novelty of this paper lies in its examination of the latest wave of blockchain projects in science, particularly the emergence of DAOs and DeSci in the years 2021-2023, an analysis that is still largely absent from scholarly literature. It underscores the evolving blockchain ideologies and controversies within the scientific community, as well as the tensions between transparency and decentralization.The paper highlights the practical significance of blockchain technology in academia, particularly in facilitating research funding, transparent decision-making, and cross-border collaboration. It discusses how blockchain and NFTs offer innovative ways to monetize research and democratize funding, reducing dependence on traditional funding sources.

Key words: blockchain, academia, DAO, NFT, Covid-19, decentralization

For citation: Kosmarski, A. Blockchain for Science, from Covid-19 towards DeSci: the Implementation of Decentralized Technologies in Young Academia. *Law & Digital Technologies 3(2): 37–43*

Acknowledgements: The article was prepared at the State Academic University for the Humanities within the framework of the state assignment of the Ministry of Science and Higher Education of the Russian Federation (topic NoFZNF-2023-0003 "Traditions and values of society: mechanisms of formation and transformation in the context of global history").

INTRODUCTION

This paper continues a series of studies by the author devoted to the problems of implementation and use of blockchain technologies in the sphere of science (Kosmarski 2019; Antopolskiy et al. 2019), started in 2019, at the time of active interest in this relatively new technology and the first attempts to solve various problems of the academic industry with its help – both in Russia and in across the globe. In my previous research I paid special attention not so much to the technical peculiarities of blockchain as to the social, organizational, cultural, and legal collisions that arose when it entered an area relatively distant from IT and financial technologies. It is important to note that, contrary to pessimistic forecasts about the blockchain's unnecessary use, labor-intensiveness of its use, wariness on the part of the scientific community, etc., new principles and practices of successful dissemination of decentralized blockchain solutions in science are emerging. This paper is devoted to the problems of the latest wave of such projects (2021-2023).

BLOCKCHAIN AND SCIENCE: THE FIRST ENGAGEMENTS

However, let us begin with a brief description of what blockchain is and what the principles of its implementation in academia have been. Blockchain technology, or, as it is technically more accurately called, distributed ledger technology (DLT), extended itself beyond the boundaries of specialized developments and gained global popularity in the mid-2010s (Herian 2018; Campbell-Verduyn and Hütten 2019; Voshgmir 2020).

In essence, a blockchain is a set of data blocks connected by cryptographic tools in such a way as to make it impossible to change the contents of one block without changing the others. In a digital ledger, information is stored in a network of decentralized nodes, and all recorded transactions are transparent to each member of the network. This approach to data processing (decentralized and distributed) prevents retroactive alteration of data and other types of covert manipulation.

The blockchain network relies on a consensus mechanism to ensure the accuracy of transactions without requiring trust in the actions of individual participants (Werbach 2018). Blockchain allows verification of the status of data of any kind (time of its creation or modification, authorship, content), and verification is performed by a distributed network of computers (nodes) that does not belong to a single person or organization. Thus, this technology provides a system that is resistant to unfair interventions and manipulations and, at the same time, open to the approval of all sorts of data and operations with it (Waal et al. 2020).

In a distributed registry, the data is:

– transparent;
– verifiable;
– immutable (it is technically impossible to change them retroactively without leaving a clear trace in the system);
– distributed across different nodes in multiple copies;
– decentralized (included and removed from the system based on the consensus of all participants rather than one central node of authority).

The reason for the initial interest of scientists, scientific administrators, and IT-enthusiasts close to science in blockchain was due to the fact that this technology was supposed to improve all sorts of "grand" systems of economy, politics, and society. Its key benefits were a guarantee of data stability, a guarantee of trust among distrustful entities, and a guarantee of successful interactions between these entities without the need for a central governing body. Optimism was aroused by the deep, structural similarities between science (as a social institution) and blockchain: it is just as decentralized (there is no main authority that decides everything) and develops thanks to networks of trust and agreements within the community. Or, in another formulation, "scientific data is inherently a large, dynamic corpus of information that is collectively (collaboratively) created, modified, used, and exchanged - which aligns perfectly with blockchain technology." (van Rossum, 2017, 8).

However, contrary to this structural similarity, at the level of management, funding, peer review, applied scientometrics, and expert evaluation, there are many opaque "black boxes" in science – systems whose processes are closed and opaque (Bunge 1963). How does the selection of reviewers for a manuscript submitted to a journal - and decision-making about the publication of this manuscript in general - take place? By whom and on the basis of what indicators is the level and quality of a scientist's work evaluated? How and by whom are grant recipients determined? The insularity of these processes from the scientific community, their inertia, bureaucratization, and corruption often cause justifiable dissatisfaction among scientists (Fanelli 2009; Head et al. 2015). It was expected that the application of blockchain in science would at least unlock some of the "black boxes" and make the processes inside them more open, reliable, and decentralized.

The main directions of blockchain adoption in science for 2017-2020 can be summarized as follows (for more details see Kosmarski 2019; Leible et al. 2019):

– Decentralization of decision-making, elimination of intermediaries;
– A new level of transparency - against data manipulation, behind-the-scenes decisions by journal editors and administrators;
– Against the monopoly of large commercial publishers profiting from scientists: instead of journals, open publication platforms where authors and reviewers interact directly;
– New tools for funding and fundraising through cryptocurrency instruments, independence from the state (crowdfunding 2.0);

– Infrastructure for innovation in science, testing new tools for working with data, project management, fixing intellectual property rights, raising funds for research;
– Time-stamped texts on blockchain with authenticated identity of the author allows for the assertion of priority and intellectual property rights;
– Uploading data to the blockchain, which is open to the research community, makes it difficult to manipulate the data at the analysis stage to get the right result;
– Accounting and distribution of grants on smart contracts (money is allocated only if certain conditions are met).

However, even back in those years, contradictions between the basic principles, or worldviews, behind specific projects and solutions emerged and began to grow. First of all, between "governmentality" which emphasized the importance of the transparency of processes brought by blockchain, the forced transparency of everything that a scientist, scientific editor, administrator, etc. does, transparency that was proposed to be implemented by administrative methods, on the one hand, and "democracy" where the main emphasis was placed on decentralization, giving individual scientists more authority to manage science, to determine where a particular discipline should develop, what projects to support - that is, in general, republican ideas (Bychkova and Kosmarski 2021).

In addition, another contradiction was mounting: blockchain was intended to create an autonomous, self-regulating system of academia run by the scientists themselves, a self-governing sphere stimulating scientific progress - but it is based on a race for material incentives, attracting funds not from the state but from independent investors through cryptocurrency instruments. This kind of commercial logic is often perceived by scientists as corrupting the scientific community and hitting the principles of the disinterested search for truth (more on these blockchain ideologies and related controversies see: Manski and Manski 2018; Kosmarski 2020). Finally, much of the difficulty in implementing the new technology has been created by the gap between its reputation, expectations of it, and the actual integration of DLT into the workflows of scientific organizations. The functionality and interface of existing applications were inferior to collaborative tools such as Google Docs or Facebook. A separate problem is the uncertain legal status of cryptocurrencies, smart contracts and other blockchain tools in the Russian Federation and some other countries (Antopolskiy et al. 2019).

BLOCKCHAIN AND COVID-19

The challenges and contradictions described above, as well as the global shift toward a "state-run" blockchain as early as 2020 (for example, the simultaneous ban on cryptocurrency mining and the transition to the digital yuan in the People's Republic of China, the tightening of regulation of the cryptoeconomy in the United States), and, in general, the increasing state sovereignty in the era of the pandemic, have led to a halt (or at least a freeze) of the vast majority of blockchain initiatives in the field of science. Two years into the pandemic have forced representatives of blockchain-related science startups and related projects to throw their energies into applying distributed ledger technologies to solve the Covid-19-related societal problems.

The Covid-19 pandemic has led to a dramatic expansion of digital applications. This was caused by quarantines, lockdowns, and extraordinary social distancing. The most obvious example was the mass transfer of employees of companies, educational institutions, even government agencies to remote work (Branscombe 2019). Even with a rapid return to normal, pre-pandemic life, the radical shifts in the digital economy are not going to disappear - in all likelihood, the world will have to live in constant readiness for new quarantines and Covid-like bio-threats. Accordingly, the problems of online payments, data protection, internet security, and the regulation of online practices in general are becoming more pressing than ever.

Even in the medical field, new digital technologies are being actively used in the fight against Covid-19: first of all artificial intelligence techniques used both in drug and vaccine development and for rapid diagnostics (Vaishya et al. 2020). but also drones, for tracking quarantine violators and spraying disinfectants (Leite et al. 2020).

What is the place of distributed ledger technologies in the digital "first aid" to the world? First of all, blockchain "shook out" in the Covid era also by actualization of its very first and most popular realization in the economy. The value of cryptocurrencies on the market, the volume of trading with them rose sharply during the pandemic: cryptoassets coped with the role of a "safe harbor" during unexpected perturbations in the financial markets (Corbet et al. 2020). Blockchain is similar to the coronavirus, paradoxically, in that both phenomena themselves, as a source of hype, have affected companies: firms with the word “blockchain” in their name and product description have seen their capitalization rise, while those unfortunate enough to own a “corona” have seen their capitalization fall.

Further, Covid-19 has made many areas of blockchain application relevant, where already, in 2018-2019, there were active developments and successful implementation experiments. First of all, this is work with any kind of supply chain - distributed registry as a technology for tracking the movement of goods from the manufacturer to the store. Blockchain allows for unified accountability and, in the case, for example, of a product that has caused food poisoning, to quickly trace its source and remove the entire shipment from sale (Sharma et al. 2020; Tönnissen et al. 2020).

However, the pandemic has highlighted an even more pressing problem: private companies, and especially the state, have demanded and seized huge amounts of personal data, including health data. This is not surprising - people's health and its monitoring became a matter of state security. However, a side effect of this process is that people have lost control over what happens to information about their bodies, where it is stored, and how it is used. The data gets stored in closed databases of insurance and pharmaceutical companies, Internet giants and IT companies (manufacturers of wearable devices), clinics and ministries of health, where it is often defenseless against attacks by hackers (Cimpanu 2019). In other words, the pandemic has reinforced the need to simultaneously coordinate between very different and often conflicting organizations (and preferably on a cross-border, global scale - to coordinate the fight against the coronavirus) and protect the data privacy of millions of individuals. Blockchain technology, which simultaneously makes data immutable, unified and decentralized, has proven to resolve this paradox.

The most ambitious project in this direction is MiPasa, a multi-party, multi-source verifiable data sharing platform launched with the support of IBM, Oracle, the Linux Foundation and the World Health Organization to collect and share data from multiple verified sources, from the same WHO to hard-to-find statistics from local health departments, clinics and even individuals, while keeping the data anonymous. MiPasa is intended as an analytical tool to predict potential hotspots and Covid-19 outbreaks early on. Interestingly, the cryptographic means of data protection and the global scale of the project make it possible to remove the level of the state (leaving only individuals, the platform and international scientific and medical structures), which raises the most concerns in terms of data abuse and attacks on personal freedoms (Kiranmayee et al. 2022).

Cov-ID, a blockchain application that conducts status checks and tracks contacts of infected individuals, and rewards healthy citizens for voluntary self-isolation with tokens, accomplishes a similar task in a single country (South Africa). The app runs on Sovrin's SSI network, allowing users to maintain complete anonymity and control over their data, while giving away vital information about the spread of infection. In general, this is the mainstream of the “blockchain and Covid-19” theme: developing protocols or applications that solve epidemiological problems (contact tracing, social distance) using mobile devices while preserving user anonymity. These include the CovidChain project (Choudhury et al. 2020), BeepTrace (Xu et al. 2020), and the /textit protocol, which uses the Internet of Things in addition to blockchain (Lv et al. 2020).

THE NEW WAVE OF BLOCKCHAIN FOR YOUTH SCIENCE: DAO AND DeSci

The years 2022-2023 were marked by a new wave of international blockchain projects, primarily related to DAOs (decentralized autonomous organizations) and the concept of DeSci (decentralized science). In short, blockchain as a tool for building transparency and automating science is no longer relevant, and it is its decentralization aspects, along with tools for attracting funding for scientific research, that are in high demand.

The DAO tool emerged in the IT environment in 2017 but has only recently become mainstream, with practical and usable solutions such as Aragon DAO. DAOs are open, self-organizing networks whose participants cooperate to achieve common goals. They are based on a set of rules: transparent, defined by system users and independent from a central management body. DAO as an organization is governed by the rules encoded in the form of computer programs in the blockchain network. These rules are enforced by smart contracts, which are self-executing contracts in which the terms of agreement between participants are written directly into lines of code. DAOs are decentralized, meaning that they are not controlled by any one organization or individual, but rather by a network of participants who hold tokens that represent their "voting rights" in the organization. DAOs can be used for a variety of purposes, including crowdfunding, decision-making, and governance.

Among the advantages of DAO as an organizational form are the following:

1. Decentralization: DAOs are not controlled by any entity or individual, which makes them more resistant to hacker attacks and bureaucratic hurdles.
2. Transparency: All transactions and decisions made within a DAO are recorded on the blockchain, making them transparent.
3. Efficiency: DAOs are based on smart contracts that automate many processes and reduce the need for intermediaries, making them more efficient.

However, DAOs are not without serious drawbacks:

1. Lack of regulation: currently DAOs are not regulated by the government, which can lead to legal problems.
2. Complexity: The blockchain technology underlying DAOs is difficult to understand and utilize.
3. Lack of human oversight: DAOs are run by computer programs, which means there is no human oversight or interference in decision-making processes. This can lead to unintended consequences or decisions that are not in the best interest of the participants (Feichtinger et al. 2023).

Speaking specifically about the science, DAO is a network of academics who come together for a common goal (collaboration), define basic rules (those are fixed in smart contracts). And then the real life begins: producing and curating content, gaining reputation, voting and making decisions (about money, content, community composition, etc.). Smart contracts automatically execute decisions. DAOs in science may be used for the following purposes:

1. Research crowdfunding: DAOs allow raising funds from broad groups of Internet users and any kind of organization, not only scientific ones.
2. Decentralized decision-making: with DAOs, decisions about which research projects to fund can be made in a decentralized and transparent way, with stakeholders having a say in the process.
3. Cross-border collaboration: DAOs can facilitate collaboration between researchers from different institutions and countries, allowing for more diverse and interdisciplinary research teams (for more on these developments see Ducree et al., 2022).

Overall, DAOs have the potential to democratize scientific research and make it more accessible, transparent and collaborative. In addition to DAOs, blockchain projects in science have been revitalized by the explosive growth of the market for so-called NFTs, non-fungible tokens that provide ownership and authenticity of digital assets. NFTs can be used to create digital objects that represent scientific discoveries or breakthroughs.

For example, a group of researchers can create an NFT representing the discovery of a new gene, which can then be sold to interested parties to support further research. This gives scientists a new way to monetize their research and innovation. Generally speaking, NFTs have serious potential to democratize the funding and organization of science. They provide a more accessible way for individuals and organizations to support scientific research and innovation. This can help reduce reliance on traditional sources of funding such as government grants or corporate sponsorship.

CONCLUSION

Finally, a series of conflicts between different countries, block and even macrolevel entities in 2022-2023 have drastically undermined the very premise of globalization, on the basis of which the whole array of blockchain projects and imaginaries had been founded. In times of war, the utility of blockchain for scientific cooperation becomes questionable.

Geopolitical tensions and mistrust among nations make decentralized systems a double-edged sword. Participants from conflicting nations may be hesitant to rely on a blockchain network managed by a decentralized global community, fearing potential manipulation or interference from their adversaries. In such an environment, the trust deficit overshadows the benefits of decentralization, rendering blockchain an unsuitable tool. Furthermore, international scientific cooperation during times of war is subject to strict regulatory controls and export restrictions, imposed by both participating nations and international bodies. Blockchain's decentralized and borderless nature can pose compliance challenges when adhering to these regulations. Researchers and institutions may inadvertently run afoul of export controls by sharing controlled technologies or information on a blockchain, leading to legal consequences and international disputes that impede cooperation. Researchers and institutions from countries in conflict may face domestic pressure to abstain from collaboration with entities from opposing nations, even on benign scientific endeavors. These political sensitivities can deter participation in blockchain-based networks that are perceived as operating beyond national control.

The future of blockchain for science remains uncertain. As the world navigates the complex landscape of geopolitical conflicts, addressing these challenges requires careful consideration of both the advantages and limitations of blockchain in the context of scientific collaboration. It also highlights the need for diplomacy, international cooperation, and innovative strategies to bridge divides and foster scientific advancement during tumultuous times.

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