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Can decentralized science help tackle the deterioration in working conditions in academia?

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Academic staff's working conditions have been deteriorating for years. In particular, the reduced availability of both research funding and permanent research positions has continuously led to insidious competition and intense stress among academics. Whereas governing bodies have made significant attempts to narrow pervasive social inequalities in the distribution of research funding within the scientific community, they have not truly taken into account the importance of the academics' overall well-being in the development of more sustainable financing of academic researchers. This originates not only from the complexity to develop comprehensive models reflecting staff's overall well-being in the academic environment, but also from the limited access to reliable and immutable data that transparently account for the staff's direct experience. In this context, blockchain technology can push further the use of more transparent survey data collection and record-keeping that can help mitigate the systematic bias inherent to the centralized nature of traditional auditing. We discuss how research institutions and governing bodies can build on blockchain technology and the early momentum generated by the decentralized science (DeSci) movement to implement the future-proof research funding chain that values overall well-being across academia in a transparent and coordinated way.

KEYWORDS

research funding policy, funding inequalities, working conditions, wellbeing, blockchain, decentralized science

1 Introduction

Modern science has never been so competitive. The reputation and prestige arising from transformative research discoveries give scientists an incentive to share their knowledge with the community but also ensure that individuals and research teams compete. In the current scientific landscape, the imposition of reputation systems that shape the career of researchers or the prestige of their institutions remains mainly based on their success in obtaining a high level of grant funding. However, the reduced availability of both research funding and permanent research positions has made modern science more competitive than ever. This has progressively led to the excessive concentration of funding in a relatively small number of hands (Lauer and Roychowdhury, 2021), which has deepened social inequalities and geographic disparities in both funding resources and non-permanent staff recruitment. The latter has happened at the expense of the quality of scientific mentorship and workplace arrangement, including harassment, pernicious competition, perverse micro-management objectives and the generalization of hot desking, which impacts the staff's overall wellbeing (Gewin, 2022). This insidious competition and intense stress are continuously driving young talented researchers away from careers in science, and this may be particularly true for young female scientists (Newsome, 2008; Adamo, 2013; Fathima et al., 2020).

Lately, governing bodies have done significant attempts to narrow pervasive social inequalities in the distribution of research funding within the scientific community (Lauer and Roychowdhury, 2021; Pichon, 2021). This includes the creation of anti-racism commitment authorities and advisory groups to address the underrepresentation of marginalized scientists. Some governing bodies have also imposed objectives relative to diversity and inclusion in individual investigators' performance development reviews and implemented alternative research initiatives that target funds directly towards early career investigators (Lauer et al., 2017). However, the importance of the academic working environment as well as the staff's overall well-being, which remains central to fostering scientific creativity (Amabile, 1996), has not been truly considered by institutions and governing bodies in the development of more equitable and sustainable financing of academic researchers. This originates in large part from the difficulty in objectively addressing the deterioration in working conditions in academia, which comes not only from the complexity to develop comprehensive models and metrics reflecting academic staff's individual well-being and the influence of the immediate working environment (Ruggeri et al., 2020), but also from the limited access to reliable and immutable data that transparently account for the direct experience of staff (RSC, 2018).

To push further the implementation of a more sustainable research funding chain that traces securely the deterioration in working conditions and overall well-being of the academic staff as part of the healthy functioning of academic institutions, governing bodies and research institutions must engage in transformative actions to overcome the limitations coming from the centralized nature of the current measures. In particular, the absence of trustless distributed ledgers, where data is secure and free from external manipulation, remains a major impediment to the monitoring of a transparent evaluation of staff's well-being that draws directly from the experience of staff instead of external auditors that commonly lack objectivity. Consequently, it makes it difficult for institutions and governing bodies to better understand the barriers and causes of well-being support needs and workplace dysfunction that exist across academia. It also prevents them to work closely together to cooperatively implement a research funding chain that addresses these inequalities and reassures academic participants that their voices and concerns are listened to and cannot be manipulated while remaining pseudo-anonymous.

2 A decentralized solution

In this perspective, academic institutions and governing bodies can build on blockchain technology and the early momentum generated by the decentralized science (DeSci) movement to implement a transformative solution to help trace securely the deterioration in working conditions, in particular, the average standard of overall well-being across research institutions, in a transparent and coordinated way. DeSci has recently emerged as both a scientific community movement and an alternative scientific infrastructure built on top of the blockchain to improve the modern organisation of science by addressing some important research pain points, silos, and bottlenecks (Hamburg, 2021). From a technical standpoint, blockchain is a distributed ledger technology that empowers anyone with an internet connection to transfer any valuable digital asset, such as currency, software code, document, or survey answers, with unmatched security and integrity (Casino et al., 2019). It builds on a decentralized, peer-to-peer network where the data and its change history are securely organized in a chain of cryptographically linked blocks to make them resilient against unintentional or malicious manipulation while being accessible to everyone on the network (Zheng et al., 2017). Potential use cases for blockchain have now spread far beyond the sole cryptocurrency domain initiated by bitcoin in 2008 (Nakamoto, 2008), including manufacturing supply chain management (Kim and Laskowski, 2018), digital identity (Zwitter et al., 2020), financial services (Treleaven et al., 2017), clinical research (Charles et al., 2019), science communication (Coelho and Brandao, 2019), and intellectual property rights (Wang et al., 2019), among others. In this context, DeSci lies at the intersection of the Open Science initiative (Woelfle et al., 2011), which aims to make scientific research and its dissemination accessible to all levels of society, and the Cypherpunk movement promoting a decentralized and encrypted operating model of governance (Jarvis, 2022), thought by many to be the grandfather of cryptocurrencies and blockchain technology.

Whereas compliance audits are traditionally used by academic institutions and governing bodies to tackle predetermined inequalities across research institutions, they intrinsically come with a lack of objectivity and transparency due to the centralized nature of the audit process. This diminishes the collegiate culture of trust which limits the availability of data and undermines the efforts to develop responsive and appropriate interventions (Holligan and Sirkeci, 2011). Therefore, it has become desirable to combine systemic evaluation models of well-being, which encompass both

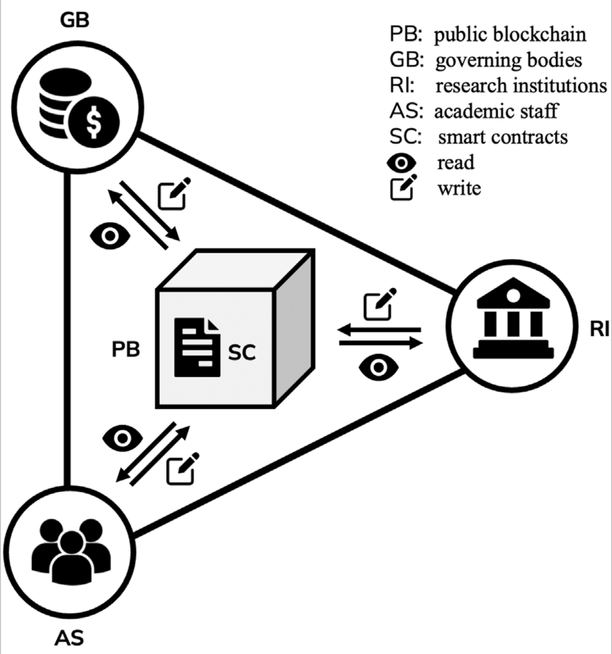

FIGURE 1
Relation between the different participants in the blockchain layer added to the decision-making ecosystem. Research institutions (RI) and governing bodies (GB) cooperatively implement a systemic well-being strategy, which is securely stored and openly accessible on the blockchain network (PB) as smart contracts (SC). The direct experience of the academic staff (AS) is transparently collected by an open-source web-based platform and software oracles which interact with the smart contracts. Individual answers are made pseudo-anonymous and stored on the blockchain network along with the survey outcomes. Data remains openly and securely accessible to the different participants in the network.

the holistic development (Weziak-Bialowolska et al., 2021) of the academic staff and the influence of the immediate working environment, with the openness and immutability of the blockchain. This could circumvent the lack of trust and transparency of traditional compliance audit procedures and help achieve a better understanding of staff's individual well-being and workplace culture.

Specifically, when blockchain technology is used to securely monitor the overall well-being of the academic staff, the well-being assessment protocols are openly accessible on the blockchain network, where they are securely stored as smart contracts, *i.e.*, autonomous pieces of code programmed using a procedural language that executes upon fulfilment of certain conditions and enjoy all the features of the blockchain (such as decentralization, immutability, and validity) (Vigliotti, 2021). Traditional attributes such as research outputs and activities, workplace resources, and ascriptive characteristics (age range, gender, race), are collected from research institutions. Just as importantly, cultural information related to individual staff well-being (mentorship, recognition, autonomy, financial stability, mental and physical health) is directly collected from academic staff (permanent and non-permanent) to guarantee the inclusivity and objectivity of the survey. Traditional and cultural attributes, which serve as input to well-being assessment models, are independantly queried by software oracles, *i.e.,* digital interfaces linking off-chain information to on-chain infrastructures (Poblet et al., 2020), to protect individual privacy and are sent automatically to smart contracts that self-execute on the blockchain. In this process, research institutions, governing bodies, and academic staff, which are participants in the blockchain, are using either permanent or temporary identifiers, or digital signatures, which they use to interact with the smart contracts and sign the transactions they add to the blockchain (see Figure 1). The different attributes (well-being strategy, traditional and cultural information) are hashed, *i.e.,* one-way encrypted, to assure immutability and mitigate threats to data privacy (Morrow and Zarrebini, 2019). Every step of the process is immutably recorded on the blockchain and openly accessible to every participant. Governing bodies can then query the smart contract to access survey outcomes, which build on reliable and immutable data. They can therefore transparently implement strategic plans promoting equality, diversity, and inclusion in academia or leverage the allocation of additional research funding to push research institutions into taking responsive actions to create an environment that encourages positive change.

The wider adoption of blockchain technology accross academia would help improve how research institutions and governing bodies tackle the deterioration in working conditions and overall wellbeing without having to conduct physical audits and financial reviews, which can be tedious and error-prone. Most importantly, it would offer a secure and decentralized ledger with tamper-resistant records, which would reassure academic participants that their voices and concerns cannot be manipulated and remain pseudo-anonymous. Adding a blockchain layer to the decision-making ecosystems would offer a transparent and sustainable approach to avoid sacrificing good data for privacy, undermining the efforts to develop responsive interventions. The community-led development of an open-source web-based platform spearheaded by the DeSci community and powered by, for example, the Ethereum blockchain (Buterin, 2014), which is transparent, immutable, and auditable, would give the data added value and integrity, as well as peace of mind for the participants. Open source would also assure that every stakeholder can adopt this tool to create an institution-wide data ecosystem that remains flexible and adaptable.

3 Discussion

To help accelerate the pace of change and push further the creation of the future-proof research funding chain that traces securely and objectively the deterioration in working conditions in academia, research institutions and governing bodies can build on blockchain technologies and the early momentum generated by the decentralized science community movement to improve the collection, scrutiny, and sharing of meaningful and reliable data that transparently describes the average standard of overall well-being across the academic community. In this perspective, it is essential that DeSci does not distance itself from existing academic institutions and governing bodies, but cooperatively promote open discussion on how consensus decision-making can be sustainably brought back in the scientific community to ensure that all opinions, ideas and concerns are taken into account to encourage a more open culture for disclosure.

From a technical standpoint, blockchain technology is still seen as a relatively new technology with its own drawbacks and challenges, including regulatory risks and a lack of well-defined use cases, which is hindering mass adoption. However, it is progressively impacting positively many industries and is becoming a more well-known area in the academic space. Whereas blockchain technology itself is not sufficient to tackle the deterioration in working condition in academia, it can strategically support the implementation of well-being assessment plans and academic responsive actions. In this perspective, it is essential to take into account both challenges and potential solutions to compliance with the Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation, GDPR), in particular the right to erasure ('right to be forgotten') of personal data which appears in GDPR art. 17 (Finck, 2018). Whereas GDPR does not apply to anonymized data that cannot be traced back to an individual person, cryptographic hash functions, which are fundamental for blockchain technologies, accomplish only pseudonymisation and are not sufficient to comply with GDPR when personally identifiable information (PII) is stored on-chain (Finck and Pallas, 2020). It is therefore desirable to avoid or limit the use of on-chain storage for PII, which can affect individual privacy. In particular, the use of decentralized well-being assessment protocols that do not explicitly contain PII, along with temporary digital signatures would provide a sustainable solution in compliance with GDPR.

Finally, the implementation of a blockchain record-keeping layer focusing equally on research achievements and wellbeing-related information, which would complement the traditional off-chain ecosystem of academic funding attribution, could become a key element of DeSci in building securely a future-proof research funding chain which brings back consensus decision-making in academia. It would help keep governing bodies and academic institutions transparently accountable to academic staff regarding their engagement in favor of a research environment which encourages positive change. It would also provides a sustainable blockchain-based solution that circumvents the limitations of centralized governance structure for data management by preserving the integrity of the data that transparently account for the staff's direct experience. This could favour and empower smaller institutions and underrepresented scientific communities, which have the potential to offer appropriate working conditions, value mental wellbeing and support sustainable knowledge transfer *via* dedicated mentorship, essential to foster scientific creativity.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

The author confirms being the sole contributor of this work and has approved it for publication.

Conflict of interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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