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EDITORIAL

The Internet of Value: Unleashing the Blockchain's Potential with Tokenization

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1 Introduction

Blockchain technology's peak of inflated expectations was reached during the fall of 2021, when cryptocurrency prices reached all-time highs, with a total market capitalization of about US$ 3 trillion.[1] After the speculative frenzy, market capitalizations significantly shrank to below US$1 trillion, and since the introduction and quick adoption of Artificial Intelligence, blockchain technology has attracted less public attention.

However, with recent rising regulatory certainty, e.g., the introduction of the Markets in Crypto-Assets Directive (MiCA) (European Union 2023), the SEC's Bitcoin and ETH exchange-traded funds approvals (Lang and McGee 2024a, 2024b), and first results from the European Blockchain Regulatory Sandbox (Bird & Bird and OXYGY 2024), an increasing number of blockchain use cases have passed the "trough of disillusionment", showcasing the potentials of this technology.

In the meantime, the academic community has developed a rich and diverse research agenda (Nofer et al. 2017; Beck et al. 2017). As an emerging technology, at first, various studies focused on blockchains', smart contracts', and tokens' potential applications, e.g., their impact on business models, value chains, and ecosystems (Tönnissen et al. 2020; Weking et al. 2020; Witt and Schoop 2023), energy markets (Alt and Wende 2020), supply chain management (Tönnissen and Teuteberg 2020), mobility and logistics (Fridgen et al. 2019), financial services (Egelund-Müller et al. 2017), service management (Büttgen 2021; Seebacher and Schüritz 2017), and business process management (Mendling et al. 2018). Most recently, the impact of blockchain and crypto-economics has been recognized in a special issue of *Management Science* (Biais et al. 2023). Many of the early promises of blockchains still hold, e.g., higher exchange velocity, lower transaction costs, and digitized assets (Constantinides et al. 2018). Yet, research has deepened our understanding of how blockchain technology may create value and how it might interoperate with existing (digital) infrastructure. For instance, research has looked at the question of how smart contracts may help firms address contractual incompleteness (Chen et al. 2023) and increase contract enforcement when connecting blockchains to non-blockchain environments via oracles (Cong et al. 2024) or to the physical world via sensors (Bakos and Halaburda 2023). Moreover, blockchains may improve supply chain transparency by reliable notifications (Chod et al. 2020) or adding traceability (Iyengar et al. 2023a). In contrast, the adoption of permissioned blockchains (i.e., distributed ledgers with restricted access to their network and data) requires new means for monetization to add value for incumbents (Iyengar et al. 2023b).

Building on these insights, we argue that blockchain technology might provide an important building block of

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[1] See Fig. 2 in Sect. 2.

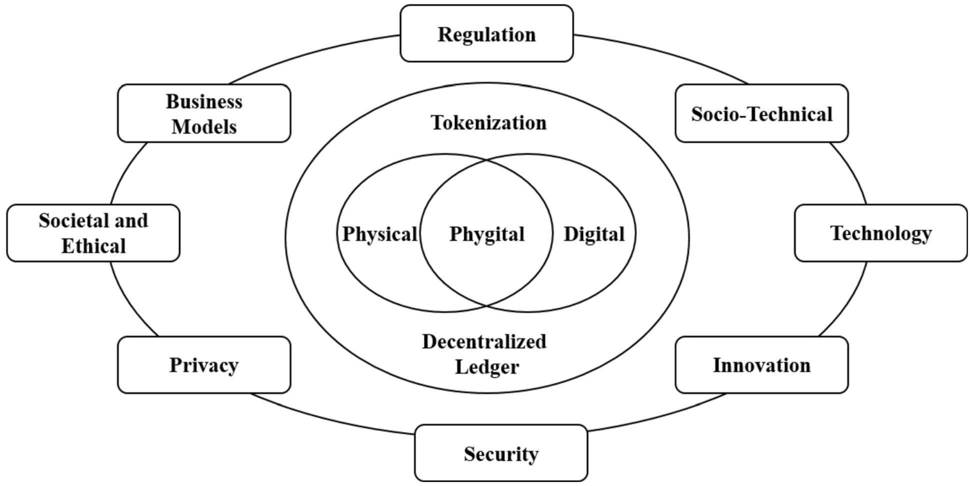


Fig. 1 Tokenization merging physical and digital realities

the infrastructure for the evolution of the Internet. Earlier versions of the Internet feature, amongst others, the "Internet of Things" (Yoo et al. 2010; Bharadwaj et al. 2013), the "Internet of People" or "Social Internet" (Kane et al. 2014; Aral et al. 2013), and the "Internet of Services" (Rai and Tang 2014; Rai et al. 2012). However, all these versions lack a native value transmission mechanism for the digital realm. Without a native value transmission mechanism, digital representations of assets in a trustless environment are abundant and lack scarcity and ownership provenance (Beck et al. 2018). Alternatively, they rely on trusted centralized parties to enforce scarcity and ownership, which exposes users to the power of these centralized parties.

The next iteration of the Internet as the "Internet of Value" enables the seamless transfer of value (money, assets, rights) across the Internet. To do so, the "Internet of Value" can rely on blockchain technology to implement a native value transmission mechanism. Moreover, it introduces decentralized digital ownership and scarcity, thereby merging the physical and digital by "tokenization." These innovations aim to reduce transaction costs, increase security, and enhance accessibility, offering substantial advantages over traditional systems.

To explain the notion of tokenization, first consider real-world assets that exist in the physical world and have an inherent value. Examples of such assets include real estate (e.g., buildings), production equipment (e.g., a milling machine), raw materials (e.g., oil), products (e.g., a car), stocks, bonds, etc. Tokenization is the process of creating a unique digital representation of such an asset in the form of a token and storing this token using cryptographic techniques. Such a digital token represents ownership or a share of the corresponding asset (Zavolokina et al. 2024). The tokenization of assets itself is not a new concept. However, tokenization has become more prevalent for various physical and digital assets. Additionally, the combination of tokenization and digital twins (van der Aalst et al. 2021) allows the enforcement of rights from the holder of the token via the digital twin on the physical asset itself. Recent studies combine blockchain and digital twin innovations for durable goods, e.g., blockchain-based certification for cars (Bauer et al. 2022), enabling the trading of physical goods on blockchains (Notheisen et al. 2017; Schär et al. 2022), and leveraging digital twins for smart markets (Kahlen et al. 2023). Thus, tokenized assets are digital representations of physical, digital, or "phygital" (i.e., digital and physical) assets. Thereby, phygital assets provide increased utility by having both physical and digital properties and functionalities that go beyond being digital representations, e.g., they could allow the enforcement of rights on the physical asset.

Following this understanding, blockchain technology provides the infrastructure layer for the "Internet of Value," and tokenization enables the creation of assets at its core (see Fig. 1). Tokenized assets are transferrable on a decentralized ledger, allowing new forms of fractionalized ownership (Whitaker and Kräussl 2020), modularity, and programmability (Risius and Spohrer 2017).

Tokenization creates new opportunities in terms of both applications and technology. The energy consumption of blockchain networks based on proof-of-work cryptocurrency mining has a negative impact on sustainability and, thus, attracted a lot of criticism (Jones et al. 2022). However, different blockchain design choices, e.g., proof-of-stake, can substantially lower energy consumption concerns (Sedlmeir et al. 2020). Additionally, tokenizing real-world assets, such as waste and carbon credits, offers a promising solution for sustainability (Erwin and Yang 2023). Tokenization also enabled new forms of analytics and decision support, e.g., process mining greatly benefits from the possibility of tracing objects (Hobeck et al. 2024).

The emergence of the "Internet of Value" progresses quickly, as the broader adoption of blockchain technology and tokenization in the economy exemplifies, e.g., in the financial and online marketing industry. Also, manufacturing industries have recognized the potential, demonstrated by the creation of intellectual property through patent applications for tokenizing products and business models.

The "Internet of Value" based on Tokenization and blockchain technology offers new avenues for process automation, data-driven insights, innovative business models, and addressing sustainability challenges. Thus, the "Internet of Value" provides a rich research context at the intersection of Business Process Management, Decision Analytics, and Digital Business Management to explore and provide an understanding of the implications and benefits of this emerging phenomenon.

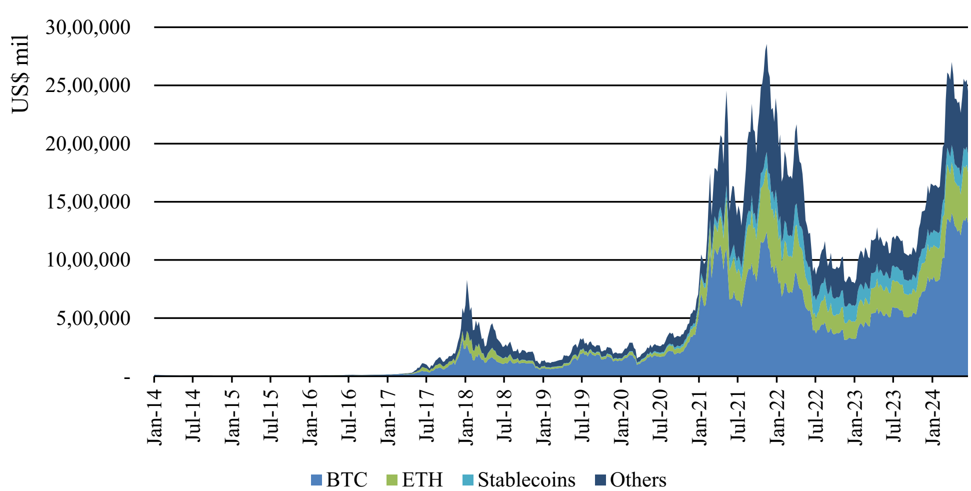
2 Status of the Internet of Value and Tokenization

Cryptocurrencies are currently still the primary use case for public and permissionless blockchains, e.g., Bitcoin or Ethereum. While the public perception focuses on speculation and fraud in the crypto industry, which are still prevalent, less attention is directed at the positive underlying technology development, which continues to innovate, such as the introduction of proof-of-stake for Ethereum in 2022 exemplifies (Ethereum Foundation 2024). The total market value of the circulating supply of all cryptocurrencies still did not fully recover from its all-time high in 2021 (see Fig. 2).

Yet, the anticipated collapse of blockchains underlying cryptocurrencies has not happened after the crash in 2021. Giving credit to the Lindy effect, i.e., which theorizes that future life expectancy of non-perishable things, like a particular technology, is proportional to their current age, anecdotally, these blockchains may continue to exist for even longer than expected by opponents. Moreover, there have been notable technological developments during the last few years. For instance, the possibility to interoperate between blockchains has risen substantially (Fig. 3). Interoperability between blockchains enhances the overall value and utility of blockchain networks by enabling the seamless transfer of assets and fostering network effects (Hinz et al. 2020). Interoperability between blockchains requires trustless protocols or trusted third parties that "bridge" tokens between blockchains. Bridging ensures that tokens are not multiplied but only "transferred" while keeping their original properties. There are various technical means to accomplish transfers of tokens between blockchains, such as "locking up" tokens on one blockchain and creating new corresponding tokens on the other blockchain or using mechanisms like atomic swaps (Herlihy 2018). This process is straightforward for simpler tokens, such as fungible tokens; however, it becomes more challenging for complex and unique tokens (e.g., non-fungible tokens, NFTs), as transferred tokens may not represent the same properties as the original token. For example, if an NFT represents a picture "on chain," destroying the original and recreating the NFT and its picture on a different blockchain may not hold the same value to (future) owners as the original NFT and its picture, even if both NFTs represent a digital picture.

Other notable technological developments relate to privacy-preserving features of blockchains, such as zero-knowledge-proofs (Principato et al. 2023), and a deeper integration and connection of blockchains to existing digital infrastructure via oracles (Cong et al. 2024). Although not all technical challenges have yet been addressed, technological development and innovations push toward

Fig. 2 Total market value of the circulating supply of all cryptocurrencies, including stablecoins and tokens (Coinmarketcap 2024)



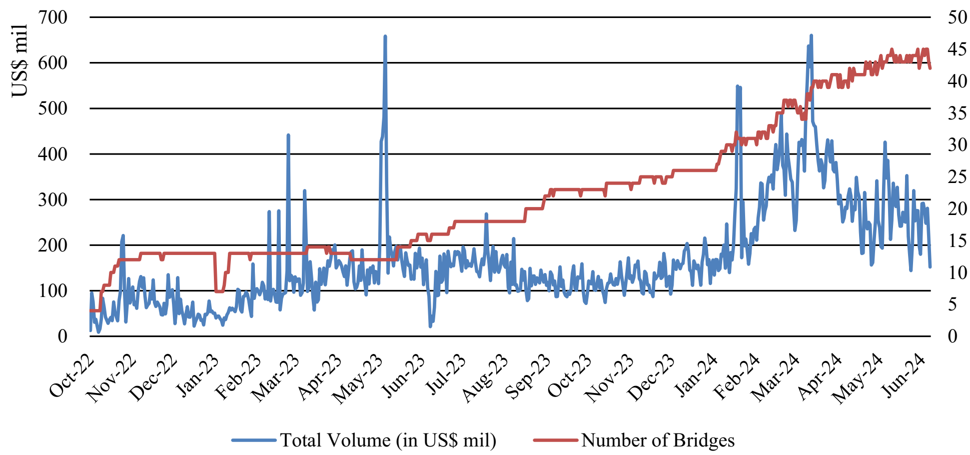


Fig. 3 Daily number of bridges and the total volume transferred via these bridges (Defillama 2024)

establishing a decentralized, interoperable infrastructure that allows the exchange of tokens and corresponding values.

Advances in the infrastructure go along with advances in the tokenization of assets. The integration of tokenized assets with existing digital environments is more evident for digital assets or assets that already have digital representations. For instance, in the financial industry, most products and services already have digital representations.

Larry Fink, CEO of BlackRock, one of the world's largest asset managers, recently assumed in an interview that almost all financial instruments will be tokenized in the future (CNBC 2024), with corresponding effects on existing business models and value chains in the financial industry. Also, the Bank of International Settlements has provided its vision for the financial sector based on tokenization and a unified ledger to create the "Finternet," e.g., Financial Internet (Carstens and Nilekani 2024). The advantages of tokenization for the financial sector include, amongst others, continuous global real-time settlements, lower operating costs, e.g., through disintermediation, and higher liquidity by fractionalizing investment opportunities globally (Sunyaev et al. 2021). Despite these advantages and bold visions, fast adoption is challenging, given the required industry-wide coordination effort to define necessary standards, interoperability requirements with legacy systems, investments into building the new infrastructure, and a fragmented global regulatory landscape (Gomber et al. 2018).

Therefore, only a small fraction of financial instruments is yet tokenized on public blockchains[2]; for example, over USD 11 billion credit volumes are backed by tokenized securities (DUNE 2024a), and over US$ 1bn shares, bonds or other (securitized) securities are tokenized (DUNE 2024b). However, tokenization in private or permissioned environments already achieves higher volumes, e.g., JP Morgan's Onyx blockchain has processed a cumulative volume of US$ 1 trillion (Ledger Insights 5/14/2024). Moreover, digital incumbents explore the possibilities, e.g., the team behind the messenger app Telegram initiated the Telegram Open Network (TON) for P2P payments within the messenger (Lutz 2024a). Thus, even with the mentioned adoption challenges, the examples demonstrate that the tokenization of financial instruments starts moving beyond the proof-of-concept stage. Moreover, countless tokenization providers are now active, offering services and know-how to tokenize other digital or intangible assets, for example, music (rights) (Lutz 2024b; Ekpo 2024); or ownership rights in companies (e.g., Tokenize.it (2024)).

Thus far, the tokenization of physical assets is prevalent and often related to making illiquid physical assets investable. Then, the tokenized assets are merely digital representations of the physical assets, granting ownership rights, typically as fractionalized ownership, e.g., for vintage car, fine wine, or real estate (see e.g., cashlink 2024). However, patent applications for the tokenization of physical assets have risen sharply in recent years (Baumann 2023) and provide an outlook of the possibilities to create phygital representations. Phygital assets combine and enhance the physical and digital capabilities of an asset. Based on patent data, manufacturers' considerations range from tokenized vehicles based on non-fungible tokens (NFTs) (Mercedes 2023), tokenized driver data with NFTs to share and monetize data (Hyundai 2023), tokenized batteries to enable rights-to-repair (Google 2022), to tokenized "wearables" such as sneakers, and the integration of their digital representation in virtual worlds (Adidas 2023; Nike 2022, 2024) (Fig. 4). The connection between the physical and digital assets also enables new business models and services, e.g., programmable decentralized license management (Intel 2022).

[2] See Beck et al. (2018) for a discussion on private versus public blockchains.

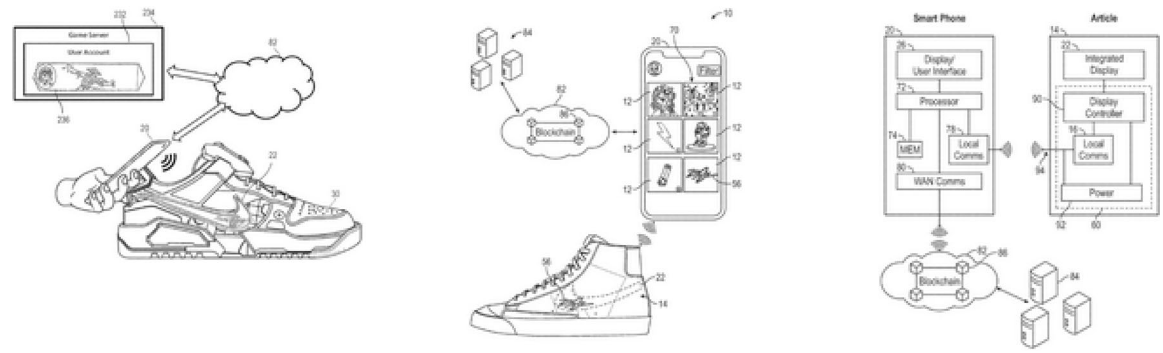


Fig. 4 Tokenized sneakers from Nike (excerpt from patent US20240012915)

These innovations demonstrate the continued trend of increasing digitalization and merging of physical products and their digital counterparts, including supplementary services (Sunyaev et al. 2021). In addition, often, these innovations foresee the implementation of regulatory considerations, e.g., by enabling the digital product passport (European Parliament and Council 2019).

Apart from tokenizing existing physical or digital assets, tokenization as an abstraction mechanism enables the representation of assets that have not yet been conceivable. For example, the provider of the Internet browser Brave (over 65 million active monthly users) tokenizes the attention of its users in the form of a token, the so-called basic attention token (BAT). Brave rewards users with BAT as advertising revenue share generated via the browser (Brave 2024). Other projects attempt to tokenize "creators" (friend.tech 2024) or "users' time" (Time.Fun 2024). These are only examples of projects experimenting and pushing the boundaries of what is possible with tokenization, what is feasible, and ultimately accepted by users and regulators. Therefore, tokenization enables new business models to be created through direct participation and incentivization of users, with potential effects on existing platforms and networks.

The rapidly advancing technical possibilities for tokenization demonstrate the need for an overarching research agenda, exploring these new developments from different perspectives.

3 Towards a Research Agenda for the "Internet of Value"

The "Internet of Value" provides countless opportunities for researchers and practitioners. Thereby, our understanding of the "Internet of Value" goes beyond the BIS's vision of a "Finternet" (Carstens and Nilekani 2024), as "Internet of Value" comprises not only financial instruments but potentially the whole spectrum of tokenized assets, e.g., physical, digital and phygital assets.

As such, a natural starting point for researchers could be to develop theoretical foundations of tokenized assets, extending our current understanding of physical and digital objects (e.g., Faulkner and Runde 2019). For instance, in contrast to existing (data) platform solutions, tokenized assets themselves become carriers and processors of data and information. This atomization and decentralization on the tokenized asset level may run counter previous trends of centralized (platform) solutions, e.g., by favoring direct-to-consumer sales and interactions, as well as de-platformization.

Moreover, from the infrastructure perspective, researchers could build on existing decentralized finance (DeFi) literature. While DeFi focuses on tokens as digital assets, it could be extended to accommodate for phygital and physical tokenized assets. Based on the DeFi tech stack (Schär 2021), we propose an initial extended conceptual framework for the tokenization of digital and physical assets (Fig. 5), which might guide researchers in approaching the "Internet of Value's" tech stack. The framework demonstrates the combinatorics and interplay of different tech stack layers, i.e., levels in the value chain, for the digital and physical world. The physical world forms the basis of asset tokenization. The framework differentiates between the representation of assets or processes (real-world representation) and the underlying value chain, including stakeholders along an asset's value chain (real-world value chain). Similar to the DeFi tech stack, tokenized assets are represented in different ways (token asset layer). The storage/settlement layer describes the storage mediums of tokens. In contrast to the DeFi tech stack, which focuses on decentralized blockchains, our conceptual framework provides for the possibility of centralized token storage solutions (centralized, traditional database), e.g., comparable to the Internet today, which exhibits walled gardens and open spaces to store

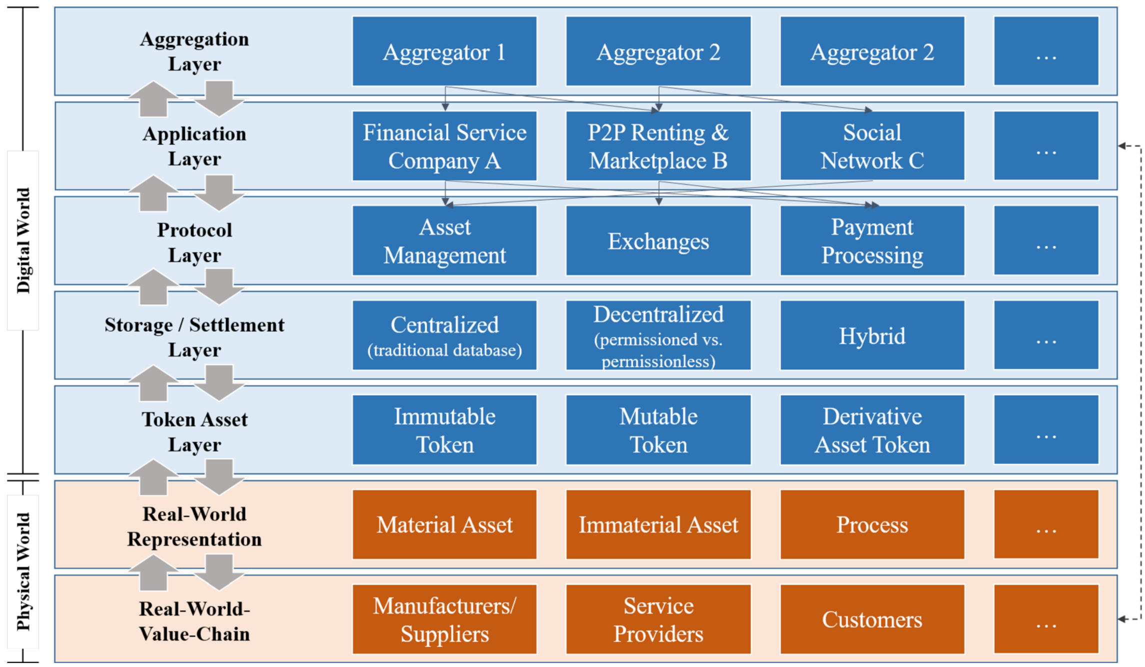


Fig. 5 Concept for the tokenization of real-world assets (based on Schär 2021)

information. The protocol layer lists examples of possible vertical solutions that are relevant in the course of the further use of tokenized assets. The application layer lists examples of (end) user applications that can be assigned to specific protocol types or use the standardized tech stack of vertical solutions to offer add-on services. It is also conceivable that applications are operated or used by stakeholders from the real-world value chain layer. Any aggregators are listed in the aggregation layer, which bundles various applications in order to generate further added value.

However, exploring the "Internet of Value" from a tech stack perspective alone will ultimately fall short. Like its predecessors, the "Internet of Value" is a complex socio-economic and technical system (Fig. 1), requiring multiple perspectives and, hence, an interdisciplinary research approach (Table 1).

Relevant subjects touch on all major topics of information systems as a discipline, from privacy and security challenges, to user and stakeholder behavior in this emerging socio-technical system, to innovation dynamics, business model innovations, and ultimately, societal and ethical implications of the "Internet of Value".

For instance, in the context of Business Process Management, researchers can explore how tokenization automates processes, while analytics and process mining from tokenized assets data allow deeper insights into asset transactions and usage, generating new insights into user behavior, market trends and better decision making (vom Brocke et al. 2021). Digital Business Management and Leadership provide important viewpoints as organizations adapt to new business models and strategies driven by decentralized technologies. After all, the emergence of the "Internet of Value" is a major digital innovation that requires digital transformation efforts on the side of its participants, potentially contributing to more sustainable business practices (Christmann et al. 2024). Thus, researchers might build on existing digital transformation literature to investigate which aspects are similar or different from previous digital transformations. This exploration might reach as far as challenging traditional concepts of business-level strategies and the role of IT (Drnevich and Croson 2013), as with the "Internet of Value" and tokenized assets, any asset becomes an information technology asset.

Moreover, the economics of information systems can provide insights into the cost–benefit analysis of adopting the "Internet of Value" across industries and address questions regarding ecosystem coordination, disintermediation, and digital transformation efforts (Plekhanov et al. 2023). Thereby, enterprise modeling and enterprise engineering are essential to understanding the structural changes required for integrating these technologies into existing systems, including potential challenges to the "Internet of Value," such as standardization and interoperability, technical debts, and (dis-) intermediation (e.g., Belchior

Table 1 Internet of value research agenda and questions

Topic	Research questions
Tokenized Assets	How does the tokenization of assets influence traditional asset valuation models and market behaviors?
	What are the implications of tokenized assets for ownership rights and transfer mechanisms across different asset classes?
Tokenization Process	What are the key technical and operational challenges in the tokenization process for various asset types?
	How can the efficiency and security of tokenization processes be improved to ensure widespread adoption and trust?
Infrastructure	What infrastructure components are essential for supporting a robust, scalable, and sustainable Internet of Value ecosystem?
	How can interoperability between different blockchain platforms and legacy systems be achieved to support the seamless transfer of tokenized assets?
Socio-Technical	How does the integration of tokenized assets impact user behavior and stakeholder interactions within the socio-technical system?
	What are the socio-technical challenges and opportunities presented by the widespread adoption of tokenization technologies?
Technology	How can emerging technologies like IoT and AI be integrated with blockchain to enhance the functionality and utility of tokenized assets?
	How can Digital Twin and IoT concepts be best integrated into tokenized assets to provide additional functionality and utility, e.g., by advanced analytics and process mining?
Innovation	How does tokenization drive innovation and sustainability in existing value chains and industries?
	What are the barriers to innovation in the tokenization space, and how can they be overcome?
Security	What are the primary security threats associated with tokenized assets, and how can they be mitigated?
	How can secure and resilient blockchain networks be developed to protect tokenized assets from cyber-attacks?
Privacy	What privacy challenges arise from the use of blockchain for tokenized assets, and how can they be addressed?
	How can privacy-preserving technologies be integrated into tokenization platforms to ensure user data protection?
Societal and Ethical	What are the societal and ethical implications of widespread tokenization of assets?
	How can ethical frameworks be developed to guide the responsible development and use of tokenization technologies?
Business Models	How does tokenization disrupt traditional business models, and what new models emerge as a result?
	What strategies can businesses adopt to leverage tokenization for competitive advantage?
Regulation	What regulatory frameworks are needed to govern the creation, transfer, and ownership of tokenized assets across different jurisdictions?
	How can regulatory bodies balance the need for innovation with the necessity of protecting investors and consumers?

et al. 2022). Finally, the "Internet of Value" and tokenization might affect users, user behavior, and consequently social dynamics. Better understanding these impacts can help design systems that enhance user experience and positive social outcomes.

In conclusion, researchers' engagement with the "Internet of Value" is crucial to fostering and steering its positive transformative potential, ensuring its emergence delivers beneficial economic, social, and technological outcomes.

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