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BLOCKCHAIN AS A MANAGEMENT TECHNOLOGY: INSTITUTIONALIZATION OF CRYPTO-ASSETS AND TRANSFORMATION OF ENTREPRENEURIAL MODELS USING THE EXAMPLE OF ETHEREUM

ABSTRACT

The rapid development of blockchain technologies creates a new paradigm of economic relations, requiring a rethinking of traditional approaches to management and business organization. The relevance of Ethereum research is due to its significant potential for creating new forms of economic coordination that go beyond existing institutional structures. With the growing complexity of global economic systems, Ethereum offers a unique approach to solving trust, transparency, and transaction efficiency problems. The purpose of the work is to substantiate the role of blockchain as a new management technology using the example of the Ethereum platform, as well as to reveal the mechanisms for projecting imaginary autonomy in the process of its design and institutionalization through the activities of various actors. The study focuses on the formation of alternative modes of economic coordination of entrepreneurial structures and social organization.

Key characteristics of the "governance through transactions" implemented in Ethereum are identified, including the focus on exchange and association relationships, the epistemological gap between the calculation and meaning of transactions, and the specific processes of forming and articulating these transactions. The process of institutionalization of the autonomy of cryptoassets is analyzed, demonstrating the complex interaction of various actors, technologies and social practices. A conceptual model of the evolution of digital economy management has been developed, reflecting the development trajectory from fragility to antifragility using the example of Ethereum. The transformational potential of Ethereum for existing economic and social structures is substantiated. This platform is considered an alternative proposal for managing the digital economy, capable of changing the fundamental principles of organizing economic activity. Problems and limitations associated with the implementation of decentralized systems are also identified, including technical challenges of scalability, difficulties of coordination, and risks of excessive algorithmization of social relations.

Keywords: blockchain, Ethereum, cryptoassets, business models, decentralized governance, smart contracts, DeFi, antifragility, philosophy of information, digital ontology

JEL Classification: G15, L26, P40, O31

INTRODUCTION

The rapid development of digital technologies is creating a new paradigm of economic relations, requiring a rethinking of traditional approaches to management and business organization. In this context, blockchain technology is of particular interest, in particular the Ethereum platform, which offers revolutionary solutions for restructuring economic interactions.

The relevance of Ethereum research is due to its potential for creating new forms of economic coordination that go beyond existing institutional structures. With the growing complexity of global economic systems and the increasing influence of environmental

factors (Ivanov et al., 2022), Ethereum offers a unique approach to addressing issues of trust, transparency, and transaction efficiency (Davidson et al., 2018; Schmeiss et al., 2019). Moreover, the study of Ethereum as a management technology is especially relevant in the context of the development of digital leadership and the transformation of corporate structures in the era of digitalization (Makedon et al., 2022).

The article focuses on a little-studied aspect of Ethereum - its role as a new governance technology. We consider how the principles embedded in the Ethereum architecture influence the formation of innovative models for organizing and coordinating economic activity.

The novelty of the work lies in the development of a conceptual model reflecting the evolution of management paradigms in the context of blockchain technologies. Drawing on the ideas of Nassim Taleb (Taleb, 2012), we explore how Ethereum can help create more adaptive and resilient economic structures by overcoming the limitations of traditional centralized systems.

This study seeks to expand the theoretical understanding of governance transformation processes in the digital era. Its findings may offer new perspectives for researchers studying the impact of technological innovation on economic and social systems, as well as for practitioners developing strategies for adapting business models to the changing conditions of the digital economy.

The study of Ethereum as a management technology requires not only technological and economic analysis but also philosophical understanding. In the context of the philosophy of information proposed by Luciano Floridi (Floridi, 2011), Ethereum can be seen as a new infosphere that transforms our understanding of economic and social interactions. The concept of digital ontology, developed in the work of David Berry (Berry,2011), provides a conceptual framework for analyzing how blockchain technologies, particularly Ethereum, change fundamental categories of being in the digital age, including concepts of ownership, identity and value. This philosophical approach allows us to better understand the transformational potential of Ethereum and its impact on the formation of new management paradigms in the digital economy.

LITERATURE REVIEW

Blockchain technologies, which emerged with the creation of Bitcoin in 2009, are attracting more and more attention from researchers as a potentially revolutionary way to organize economic and social relations. However, despite growing interest, the potential of blockchain as a governance technology remains underexplored.

Existing blockchain research covers a wide range of topics, from technical aspects to socio-economic implications. Satoshi Nakamoto, the enigmatic creator of Bitcoin, introduced the concept of blockchain as a decentralized system for conducting transactions without intermediaries in his seminal work (Nakamoto, 2008), laying the foundation for the further development of blockchain technologies.

In the context of governance, blockchain offers new coordination and decision-making mechanisms. Marcella Atzori explores the potential of blockchain to transform public administration, suggesting the possibility of creating more efficient and transparent systems. However, the author also warns of the need for careful analysis of the social and political consequences of such a transformation (Atzori, 2017). Continuing this discussion, Silvia Semenzin and co-authors present a critical analysis of the use of blockchain at the government level using the example of Estonia. Their research raises the question of whether the use of this technology is truly a revolutionary change or rather an illusion of transformation. The authors emphasize the importance of a critical approach to assessing the potential of blockchain in public administration and the need to take into account specific socio-political contexts when implementing it (Semenzin et al., 2022).

Of particular interest is the Ethereum platform, which has expanded the capabilities of the blockchain through the introduction of smart contracts. Vitalik Buterin introduced Ethereum as a universal platform for creating decentralized applications, which opened new horizons for innovation in the field of management and business organization (Buterin 2014). Gavin Wood, in his technical description of Ethereum, detailed the mechanisms of operation of the said platform, including the concept of "gas" for paying for computing resources (Wood, 2014).

In the field of entrepreneurship, blockchain creates new opportunities and challenges. Yan Chen analyzes how such technology is changing the landscape of entrepreneurial opportunities, creating new niches for innovation (Chen, 2018). Christian Fisch explores the phenomenon of Ethereum-based Initial Coin Offerings (ICOs), showing how this new form of capital raising is transforming traditional startup funding models (Fisch, 2019). Taking this topic further, Sabrina Howell and her co-authors provide a comprehensive analysis of the ICO market, looking at the success factors, risks and regulatory challenges associated with this innovative form of financing (Howell et al., 2020).

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The impact of blockchain on organizational structures is discussed in the work of Beck et al. (2018), who explore the potential of this technology to create more flexible forms of governance. Ying-Ying Hsieh and co-authors analyze the potential of blockchain to create decentralized autonomous organizations (DAOs), highlighting the potential to radically change corporate governance (Hsieh et al., 2018). Kevin Werbach's work analyzes how blockchain can change existing institutions of trust, offering new mechanisms for ensuring transparency and security of transactions (Werbach, 2018), which is important for understanding the social implications of blockchain technologies. Fabrice Lumineau and co-authors extend such debate by exploring the potential of blockchain to transform the way collaboration is organized both between and within firms (Lumineau et al., 2020). Some authors, in turn, consider the impact of blockchain on operations management, emphasizing the importance of understanding this technology for researchers in the field of operations management (Babich & Hilary, 2020).

In the context of economic theory, Sinclair Davidson and co-authors view blockchain from the perspective of institutional economics, arguing that this technology can reduce transaction costs and change the structure of economic institutions (Davidson et al., 2018). Extending this approach, Darcy Allen and co-authors analyze blockchain as an institutional technology, exploring its potential impact on innovation policy and economic development (Allen et al., 2020). A critical perspective on blockchain is provided by the work of David Golumbia, who views the technology as an extension of neoliberal logic, highlighting the risks of deregulation and the rise of market fundamentalism (Golumbia, 2016). A more balanced approach is offered by Dirk Zetsche and co-authors, analyzing the phenomenon of decentralized finance (DeFi) and its potential impact on the financial system, noting both the opportunities and risks of this new paradigm (Zetzsche et al., 2020).

Primavera De Filippi and Aaron Wright explore how blockchain can change legal and social institutions, creating new forms of "algorithmic governance." They emphasize that blockchain is not just a technology, but also a new paradigm for social coordination (De Filippi & Wright, 2018). Koray Caliskan focuses on the sociotechnical aspects of blockchain, analyzing how technology shapes new ideas about value and exchange (Caliskan, 2020). The author shows how the technical characteristics of the blockchain influence social practices and economic relations. Yingli Wang and co-authors conduct a systematic review of the literature on blockchain in business and management, identifying key research areas and gaps in the current understanding of this technology (Wang et al., 2019). Their work helps structure existing knowledge about the use of blockchain in various sectors of the economy.

Despite a growing body of research, many aspects of the impact of blockchain, and Ethereum in particular, on governance and entrepreneurship remain poorly understood. This is especially true for the long-term consequences of introducing this technology to organizational structures and business models. There is a need for a deeper theoretical understanding of blockchain as a new management paradigm that goes beyond purely technological or economic analysis.

AIMS AND OBJECTIVES

The purpose of the article is to substantiate the role of blockchain (using the example of the Ethereum platform) as a new management technology. It is necessary to reveal how imagined autonomy is projected in the design process of Ethereum and institutionalized through the activities of various actors, forming alternative modes of economic coordination of entrepreneurial structures and social organization. In this context, it is expected to develop a conceptual model for managing the digital economy, reflecting the trajectory of evolution from fragility to antifragility, as well as determining its impact on the mechanisms of transformation of business strategies.

METHODS

This study is based on a qualitative approach, which is most suitable for studying complex sociotechnical phenomena such as blockchain technologies and their impact on governance in the digital economy. The choice of a qualitative method is due to the need for a deep understanding of the context, motivations and interactions of various actors in the Ethereum ecosystem. The research methodology includes the following components:

1. Document analysis (a systematic analysis of Ethereum technical documentation was carried out, including the white paper (Buterin, 2014) and the yellow book (Wood, 2014), as well as subsequent technical updates and proposals for improving Ethereum, which made it possible to understand the technical foundations and evolution of the platform).
2. Case study (specific examples of the use of Ethereum in various sectors of the economy were considered, which made it possible to assess the practical impact of the technology on business processes and management models).

3. Theoretical synthesis (using concepts from the sociology of infrastructures Star (1999) and science and technology studies to form a theoretical framework for the analysis of Ethereum as a sociotechnical system).
4. Conceptual modelling (based on data analysis and theoretical synthesis, a conceptual model of the evolution of management in the digital economy has been developed, reflecting the transition from fragility to antifragility).

RESULTS

Perceived Autonomy in Ethereum Development: Implications for Entrepreneurial Models

The concept of a "world without centres" underlies the philosophy of Ethereum and reflects the desire of its creators to build a decentralized system, free from control by traditional institutions of power. This vision has its roots in the views of crypto-anarchism (May, 1992) and cyber-libertarianism (Barlow, 1996), which emphasize the importance of individual freedom in the digital space.

Vitalik Buterin, founder of Ethereum, describes the platform as a "world computer" (Buterin, 2014), capable of performing any calculation without centralized control. This metaphor reflects the ambitious goal of creating a global infrastructure for DApps that can operate autonomously, without the intervention of intermediaries (Wood, 2014).

The desire for "scriptural sovereignty" manifests itself in the attempt to create a system where the relationships between participants are determined solely by software code (De Filippi & Wright, 2018). This desire is embodied in the idea of smart contracts, first proposed by Nick Szabo (Szabo, 1997) and implemented in Ethereum. Smart contracts are self-executing programs that automatically execute the terms of a contract encoded in the blockchain (Buterin, 2014).

To systematize the key concepts of imaginary autonomy in Ethereum and their practical implementation, we turn to Table 1.

Table 1. Key concepts of imagined autonomy in Ethereum. *(Source: compiled by the authors based on a summary Buterin (2014), Wood (2014), De Filippi & Wright (2018))*

No.	Concept	Description	Example implementation in Ethereum
1	"A world without centres"	Decentralized system without control of traditional institutions	Distributed network of nodes
2	"World Computer"	Global computing infrastructure	Ethereum Virtual Machine (EVM)
3	"Scriptural sovereignty"	Relationships defined by code	Smart contracts
4	Distributed Trust	Trust based on cryptography and consensus	Evolution mechanisms consensus: from Proof-of-Work to Proof-of-Stake

The concepts of "a world without centres" and "distributed trust" reflect the desire for decentralization and the rejection of traditional institutions of governance and power, while the concept of a "world computer" emphasizes the ambition of the project to create a global computing infrastructure. "Scriptural sovereignty" refers to an attempt to formalize social relations through program code. It is important to note that these concepts are not just theoretical constructs, but are concretely embodied in the architecture and functionality of Ethereum.

However, as critics point out, this imagined autonomy faces a number of implementation challenges. Francesca Musiani and co-authors (Musiani et al., 2017) point out the contradictions of distributed trust in Bitcoin that also apply to Ethereum. Primavera De Filippi and Benjamin Loveluck emphasize that decentralization of control in blockchain systems often leads to new forms of centralization (De Filippi & Loveluck, 2016).

However, imagined autonomy plays a key role in shaping the discourse around Ethereum and other blockchain projects. It serves as a powerful motivating factor for developers and users seeking to create alternative economic and social structures (Swartz, 2018). It is important to note that such autonomy is not a simple technical property of the system, but rather represents a sociotechnical achievement that requires ongoing efforts on the part of various actors (Caliskan, 2020). This brings us to consider how such imagined autonomy is institutionalized through the practices and interactions of participants in the Ethereum ecosystem.

The concept of imagined autonomy in Ethereum stimulates the development of new forms of entrepreneurial activity. It is inspiring startup creators to develop innovative business models based on the principles of decentralization and programmable economic relationships, leading to the emergence of a new class of entrepreneurs who build their projects at

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the intersection of technology, finance and social engineering, rethinking traditional approaches to starting and running a business.

Having examined the concept of imagined autonomy in Ethereum, we can now move on to analyze how this idea is embodied in the specific characteristics of "transactional governance".

Key characteristics of "management through transactions" and their impact on business processes

The concept of "governance through transactions", implemented in Ethereum, is a relatively new approach to organizing economic relations. Unlike traditional forms of management that focus on individuals or organizations, this model aims to manage the very relationships of exchange and association. Let's look at the key characteristics of this model:

1. Control object: exchange and association relations. Unlike traditional forms of governance that focus on individuals or organizations, blockchain systems focus on managing relationships of exchange and association. These relationships are codified in the form of transactions, which become the basic unit of socio-economic interaction in blockchain systems. Ethereum extends this concept with smart contracts that allow complex interaction terms to be programmed (Buterin, 2014), creating the potential for the formation of new types of economic and social connections that do not depend on traditional institutions of intermediation (Wright & De Filippi, 2015).
2. The epistemological gap between calculation and meaning of transactions. One of the key features of "governance through transactions" is the epistemological gap between the process of calculation (validation of transactions) and the meaning of transactions. As Finn Brunton points out, in blockchain systems, network nodes can verify transactions without understanding their content or purpose (Brunton, 2019). This principle, which can be called "protocol mysticism," is inherited from Bitcoin and is key to ensuring decentralization and security of the system (Nakamoto, 2008). In Ethereum, it is implemented through a consensus mechanism, where miners confirm transactions and execute smart contracts without having access to their semantic content (Wood, 2014).
3. Formation and formulation of transactions. "Management through transactions" involves two key processes: the formation of transactions (their technical implementation and inclusion in the blockchain) and the formulation of transactions (determining their meaning and significance). The process of forming transactions in Ethereum is technically implemented through a network of nodes and a consensus mechanism, ensuring their immutability and transparency, which is the basis of trust in the system (Antonopoulos & Wood, 2018). The formulation of transactions, in turn, occurs at the level of development of smart contracts and DApps. Here, developers and entrepreneurs play a key role in determining what types of relationships can be encoded in the blockchain (Fisch, 2019). It is important to note that such processes are not completely autonomous or neutral. As Quinn DuPont shows with The DAO incident, the interpretation and application of the rules encoded in smart contracts can be the subject of controversy and conflict within the community (DuPont 2017).

In the context of digital ontology (Berry, 2011), Ethereum smart contracts do not simply automate the execution of agreements, but redefine the ontological status of contractual relationships, transforming them into self-executing digital entities.

For a clear comparison of traditional management and "management through transactions" implemented in blockchain systems, consider Table 2.

Table 2. Comparison of traditional management and "management through transactions". *(Source: compiled by the authors based on a summary Nakamoto (2008), Buterin (2014), Wright & De Filippi (2015), Brunton (2019))*

No.	Aspect	Traditional management	"Management through transactions"
1	Control object	Individuals or organizations	Relationships of exchange and association
2	The basis of trust	Institutions and laws	Cryptography and Consensus
3	Formation of rules	Centralized	Decentralized (via code)
4	Execution of contracts	Through the legal system	Automatic (smart contracts)

While traditional governance focuses on individuals or organizations, blockchain systems manage relationships of exchange and association. The basis of trust is shifting from institutions and laws to cryptography and consensus. Rule generation becomes a decentralized process implemented through code, and contract execution is automated through smart contracts. Such differences indicate a fundamental paradigm shift in governance that has the potential to transform existing socio-economic structures.

In the context of entrepreneurship, "management through transactions" opens up new opportunities for optimizing business processes and creating innovative services. Entrepreneurs can use this model to develop more efficient supply chain management systems, create new forms of digital assets, and tokenize traditional business models. This contributes to the formation of a new generation of entrepreneurs capable of operating in a programmable economy environment.

Transactional governance is thus a complex sociotechnical system where the technological capabilities of the blockchain combine with the social practices and interpretations of ecosystem participants to create new forms of coordination and governance that have the potential to transform existing economic and social structures.

Having identified the key characteristics of "transactional governance," it is important to understand how this new governance model is institutionalized through the activities of various actors in the Ethereum ecosystem.

Institutionalization of crypto-asset autonomy and its role in the transformation of entrepreneurship

The process of institutionalizing the autonomy of cryptoassets in the Ethereum ecosystem represents a complex interaction of various actors, technologies and social practices. The key aspects of this process are:

1. The role of various factors. The institutionalization of crypto-asset autonomy occurs through the activities of a wide range of participants in the Ethereum ecosystem. Developers, entrepreneurs, investors, users and regulators all contribute to creating and maintaining this autonomy. Developers play a key role in creating the technical infrastructure that enables the system to function autonomously. The Ethereum development community is actively involved in discussing and implementing protocol updates, aiming to preserve the decentralized nature of the platform despite emerging technical and governance challenges (De Filippi & Loveluck, 2016). Entrepreneurs and startups creating DApps based on Ethereum are helping to expand the functionality and applicability of the platform. Research by Christian Fisch shows how entrepreneurial activity in ICOs has contributed to the institutionalization of new forms of financing and business organization (Fisch, 2019). Investors and users, by purchasing and using crypto-assets, legitimize them as a form of value and a medium of exchange. As Bill Maurer and co-authors highlight, cryptocurrency practices are shaping new ideas about money and value (Maurer et al., 2013).
2. Semiotic autonomy and delegation of meaning. An important aspect of institutionalizing the autonomy of crypto-assets is what can be called "semiotic autonomy" - the ability of the creators of crypto-assets to determine their meaning and functions, which is especially evident in the case of utility tokens and investment tokens. As an analysis of the discourse around ICOs and utility tokens shows regulators often follow the definitions proposed by the token creators themselves (Hacker & Thomale, 2018), creating a situation where the meaning and legal status of crypto-assets are largely determined by their developers rather than traditional institutions. However, as Jannis Käll notes, such semiotic autonomy is not absolute and may conflict with existing legal and regulatory frameworks (Käll, 2018).
3. The role of cryptocurrency exchanges in ensuring convertibility. Cryptocurrency exchanges play a key role in institutionalizing the autonomy of crypto-assets by ensuring their convertibility and liquidity. Research by Alexandre Mallard and co-authors (Mallard et al., 2014) shows how exchanges are creating bridges between the world of cryptocurrencies and the traditional financial system. Exchanges not only facilitate the exchange of crypto-assets for fiat currencies but also contribute to the formation of market prices for crypto-assets, thereby participating in the process of their valorization (Caliskan & Callon, 2010), which creates a contradictory situation where the autonomy of cryptoassets partly depends on centralized institutions, which are exchanges.
4. Technical standards and practices. An important element of institutionalizing the autonomy of crypto-assets is the development and adoption of technical standards. The ERC-20, ERC-721, and other token standards developed by the Ethereum community play a key role in ensuring interoperability and interoperability among various cryptoassets (Vogelsteller & Buterin, 2015). These standards not only facilitate the technical implementation of new crypto-assets but also help shape common practices and expectations across the ecosystem. As Finn Brunton notes, technical standards in blockchain systems often serve a function similar to legal norms in traditional institutions (Brunton, 2019).

The institutionalization of the autonomy of crypto-assets can be interpreted as the formation of a new ontological category in the digital economy (Berry, 2011), where virtual assets acquire a status comparable to traditional forms of value.

To systematize the roles of various actors in the process of institutionalizing the autonomy of cryptoassets, let us turn to Table 3.

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Table 3. Roles of various actors in the institutionalization of crypto-asset autonomy. *(Source: compiled by the authors based on a summary De Filippi & Loveluck (2016), Fisch (2019), Maurer et al. (2013), Hacker & Thomale (2018))*

No.	Actor	Role	Example in the Ethereum ecosystem
1	Developers	Creation of technical infrastructure	Implementing protocol updates
2	Entrepreneurs	Creation of DApps and new business models	Launch of ICO and tokenized projects
3	Investors	Legitimizing crypto-assets as a form of value	Participation in ICOs and trading on crypto-currency exchanges
4	Users	Formation of usage practices	Using DApps and DeFi protocols
5	Regulators	Determination of legal status	Release of guides on ICOs and cryptocurrencies

The institutionalization of crypto-asset autonomy is the result of a complex interaction between various actors. Developers are creating technical infrastructure, entrepreneurs are experimenting with new business models, investors and users are legitimizing crypto assets through their use, and regulators are defining legal frameworks. It is important to note that the roles of these actors are not isolated, but are interconnected and often overlap, creating a dynamic and complex ecosystem.

The institutionalization of crypto-asset autonomy creates a unique ecosystem for the development of entrepreneurial initiatives. It allows startups to experiment with new forms of business organization, such as DAOs, and develop innovative financial products, stimulating the emergence of a new class of "cryptopreneurs" capable of operating effectively in conditions of high uncertainty and rapid technological change.

Thus, the institutionalization of crypto-asset autonomy is a multifaceted process in which technological innovation, social practices, and economic mechanisms interact in complex ways. This process creates new forms of economic coordination and social organization that have the potential to transform existing institutional structures.

The process of institutionalizing the autonomy of cryptoassets creates the basis for understanding Ethereum as an alternative proposal for governing the digital economy as a whole.

Ethereum as an alternative proposal for managing the digital economy

Ethereum, as an alternative proposal for governing the digital economy, offers a fundamental transformation of economic relations that affects several key aspects:

1. Ethereum as a "platform technology". One of the key features of Ethereum is its role as a "platform technology." Unlike Bitcoin, which mainly focuses on the digital money function, Ethereum provides the infrastructure for creating a variety of DApps and DAOs. As Jean-Christophe Plantin and co-authors note, platformization has become a dominant trend in the development of the digital economy (Plantin et al., 2018). Ethereum in this context offers an alternative platform model based on the principles of decentralization and openness, which creates the potential for the formation of new economic models. For example, research by Christian Catalini and Joshua Gans shows how blockchain platforms can reduce verification costs and network effects, thereby changing the structure of markets (Catalini & Gans, 2018).
2. Projection of new forms of economic organization. Ethereum serves as a framework for experimenting with new forms of economic organization. DAOs, tokenized communities, and DeFi protocols are attempts to reimagine traditional institutions in the context of the digital economy. As Quinn DuPont's analysis shows, DAOs offer a new model of corporate governance based on the direct participation of token holders (DuPont, 2017). Although this model faces several challenges, it continues to develop and evolve. DeFi protocols such as MakerDAO, Compound, and Uniswap are attempts to create a decentralized financial system that operates without traditional intermediaries (Chen & Bellavitis, 2020), which opens up opportunities for a more inclusive financial system, but also creates new risks and regulatory challenges.
3. Transformation of the concept of ownership and management. Ethereum and projects based on it offer new approaches to the concepts of ownership and governance in the digital economy. Asset tokenization, implemented through smart contracts, allows for the creation of more flexible and divisible forms of ownership (Yermack, 2017). This opens up opportunities for greater participation in economic activity and has the potential to democratize access to capital. However, as Katarina Pistor notes, such new forms of ownership also create new challenges for legal systems and regulators (Pistor, 2019).

To compare the traditional digital economy governance model and the model proposed by Ethereum, let's look at the key aspects in Table 4.

Table 4. Comparison of the traditional digital economy governance model and the model proposed by Ethereum. *(Source: compiled by the authors based on a summary Plantin et al. (2018), Catalini & Gans (2018), Chen & Bellavitis (2020), DuPont (2017))*

No.	Control characteristics	Traditional model	Ethereum model
1	Degree of centralization	High (centralized platforms and institutions)	Low (distributed network of nodes)
2	Transparency level	Limited (closed systems and processes)	High (open source and public blockchain)
3	Barriers to participation	High (regulatory and financial restrictions)	Low (open access to the platform)
4	Pace of innovation	Moderate (enterprise development cycles)	High (open development and rapid implementation)
5	Management structure	Hierarchical (corporate structures)	Distributed (consensus mechanisms and DAO)
6	Type of financial instruments	Traditional (stocks, bonds, etc.)	Programmable (tokens and smart contracts)

There are fundamental differences between the traditional digital economy governance model and the model proposed by Ethereum. Key differences are the degree of centralization, transparency, barriers to entry and speed of innovation. Ethereum offers a more decentralized, transparent and dynamic model that has the potential to lower barriers to entry and accelerate innovation. It is especially important to note the transition from hierarchical to distributed governance, which is implemented through consensus mechanisms and DAOs. In addition, the introduction of programmable financial instruments in the form of tokens and smart contracts opens up new opportunities for financial engineering and asset management.

Thus, Ethereum as an alternative proposal for managing the digital economy is a multi-faceted concept that goes far beyond just a technology platform. Acting as a "platform technology," Ethereum creates the basis for new forms of economic organization, such as DAO and DeFi protocols. This platform not only transforms the concepts of ownership and management through asset tokenization and smart contracts but also offers a more decentralized, transparent and inclusive digital economy model. However, it is important to note that implementing this model comes with a number of challenges. These include the need to develop new regulatory approaches, ensure the security and scalability of the system, and overcome potential tensions between decentralized ideals and trends towards new forms of centralization. However, the practical application of Ethereum demonstrates the significant potential of blockchain technologies for rethinking the fundamental principles of organizing economic activity in the digital era.

Having considered the theoretical aspects of Ethereum's influence on governance in the digital economy, it is important to illustrate such concepts with specific examples from various fields. Table 5 provides an overview of current applications of Ethereum technology in various industries, demonstrating the breadth and depth of its influence on modern business processes and management models.

Table 5. Ethereum as a catalyst for the transformation of management in the digital economy: from theory to practice. *(Source: compiled by the authors on basis generalizations Morgan (2023), Uniswap (2023), Etherisc (2023), Decentraland (2023), Gitcoin (2023), Energy Web Foundation (2023), OpenSea (2023), Solve.Care (2023), Ethereum Foundation (2023), Axie Infinity (2023))*

No.	Sphere	Application example	Description
1	Banking	JPM Coin	JP Morgan's digital currency for instant payments between institutional clients, powered by the bank's proprietary Onyx Digital Assets blockchain platform, which is based on technology originally developed on Ethereum
2	DeFi	Uniswap	An automated Ethereum-based token exchange system using an automatic market maker model
3	Insurance	Etherisc	Decentralized insurance platform that automates insurance payments using smart contracts
4	Virtual worlds and real estate	Decentraland	Decentralized virtual reality platform where users can create, experience and monetize content and applications
5	Crowdfunding	Gitcoin	Ethereum-based platform to fund open Web3 research and development
6	Energy	Energy Web Foundation	A project using Ethereum-based technology to create decentralized solutions in the energy sector
7	Art and digital assets	OpenSea	The largest decentralized marketplace for trading NFTs and other Ethereum-based crypto assets
8	Healthcare	Solve. Care	Ethereum-based platform for healthcare coordination, payment management and data exchange between patients, healthcare providers and insurers. Uses Ethereum smart contracts to automate processes and SOLVE tokens based on the ERC-20 standard
9	Education	Ethereum Education Alliance	An initiative to develop educational programs and resources for learning Ethereum and blockchain technology, supported by the Ethereum community
10	Gaming industry	Axie Infinity	Ethereum-based game with play-to-earn elements where players can earn cryptocurrency

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The versatility of Ethereum is striking in its scope, covering a wide range of industries - from finance and insurance to healthcare and the gaming industry. This flexibility and adaptability of technology to different business models and processes opens the door to cross-industry innovation and the formation of new ecosystems that unite diverse areas of economic activity.

Decentralization and automation are the cornerstones of many Ethereum-based projects. Prominent examples such as Etherisc in insurance or Solve. Care in healthcare clearly demonstrates the trend towards decentralized management and process automation through smart contracts. The result of this approach can be a significant reduction in transaction costs, increased efficiency and faster transaction processing. Moreover, the decentralized nature of these systems contributes to their resilience and minimization of risks associated with centralized control.

The emergence of innovative monetization models marks another important aspect of Ethereum's impact on the digital economy. Projects such as Decentraland and Axie Infinity clearly illustrate the emergence of innovative business models based on the tokenization of assets and the creation of virtual economies. This approach opens up new horizons for entrepreneurship and management in the digital space, allowing for the creation of value and monetization of assets previously considered illiquid or difficult to capitalize.

Increasing transparency and strengthening trust are becoming undeniable advantages of using Ethereum in various areas of the economy. The introduction of blockchain technology into areas such as energy (Energy Web Foundation) and crowdfunding (Gitcoin) clearly demonstrates how Ethereum contributes to increased transparency of transactions and increased trust between participants in economic relations. This aspect takes on particular significance in the context of globalization and the increasing complexity of economic relations, where traditional mechanisms for ensuring trust often demonstrate their ineffectiveness.

Integration with traditional institutions, clearly illustrated by JPMorgan Chase's JPM Coin, demonstrates the willingness of even large financial giants to implement Ethereum-inspired technology into their processes. This trend could catalyze widespread adoption of the technology and contribute to its further development and improvement. Moreover, this integration points to the potential of Ethereum to create bridges between the traditional and digital economies.

Educational initiatives such as the Ethereum Education Alliance play a key role in disseminating knowledge about the technology and training specialists to work with Ethereum, which contributes to the further development of the ecosystem and the implementation of the technology in various areas of the economy and society.

The above observations convincingly prove the role of Ethereum as a powerful catalyst for significant changes in approaches to managing the digital economy. Technology creates new paradigms for organizing and coordinating economic activity. Analysis of the functioning of Ethereum shows the significant potential of blockchain technologies for rethinking the fundamental principles of organizing economic activity in the digital era. However, to fully appreciate Ethereum's impact on digital economic governance, it is necessary to consider its evolution in a broader context.

Conceptual model of the evolution of digital economy governance: a trajectory from fragility to antifragility using the example of Ethereum

Having considered Ethereum as an alternative proposal for managing the digital economy, we can see that such a platform offers a fundamentally new approach to organizing economic relations and processes. However, to gain a deeper understanding of the potential and limitations of this management model, it is necessary to consider it through the lens of a broader conceptual framework. Of particular interest in this understanding is the concept of antifragility proposed by Nassim Taleb (Taleb, 2012), which allows us not only to assess the current state of Ethereum and similar systems but also to outline potential paths for their development in the future. In the context of blockchain technologies and, in particular, the Ethereum ecosystem, one can trace the evolution from fragile centralized systems to more resilient and, ultimately, potentially antifragile decentralized structures.

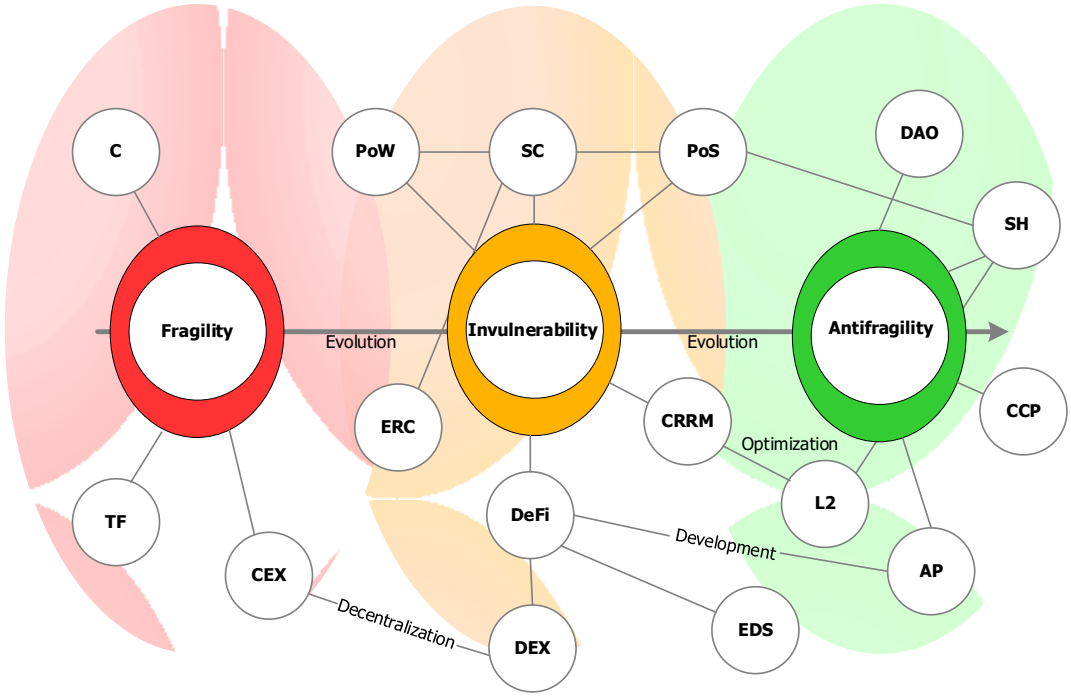
The fragility in traditional financial systems and early cryptocurrency projects is reflected in their vulnerability to various risks (Taleb, 2012): from technical failures and hacker attacks to regulatory changes and market manipulation. Centralized entities, such as traditional banks or centralized cryptocurrency exchanges (CEX), are especially susceptible to these risks due to the presence of a single point of failure. In the event of a successful attack or system failure, the consequences can be catastrophic for the entire system and its users.

The transition to invulnerability and sustainability in the Ethereum ecosystem is associated with the development of dApps, smart contracts and DeFi. These innovations make it possible to create more reliable, transparent and automated financial instruments and services. They minimize the human factor and reduce dependence on centralized intermediaries. As

Nassim Taleb notes, resilient systems are able to withstand shocks without significant change (Taleb, 2012). For example, decentralized cryptocurrency exchanges (DEXs) can significantly reduce the risks associated with storing funds on centralized platforms, giving users full control over their assets and providing greater transparency of transactions.

Antifragility in the context of blockchain technologies and cryptocurrencies refers to the ability of a system not only to withstand stress and shocks, but also to improve under their influence (Taleb, 2012), which is achieved through decentralization, open-source code, innovative consensus mechanisms and the ability to quickly adapt protocols. This concept assumes that the system becomes stronger and more effective as a result of overcoming difficulties. For example, attacks on a network can lead to the development and implementation of more advanced security protocols, strengthening the overall security of the system. Likewise, market fluctuations and economic challenges can spur the creation of more efficient financial instruments, such as algorithmic stablecoins or complex derivatives based on smart contracts.

To clearly demonstrate the evolution of the digital economy management model based on Ethereum technology, let's consider a conceptual model reflecting the development trajectory from fragile systems to antifragile structures (Figure 1). This model illustrates the key stages of transformation and relationships between the various components of the Ethereum ecosystem.



C- Centralization, SC – Smart Contracts, DAO – Decentralized Autonomous Organization, TF – traditional Finance, DeFi – Decentralized Finance, AP – Adaptive Protocols, PoW – Proof of Work, PoS – Proof of Stake, SH – Sharding, CEX – Centralized Exchange, DEX – Decentralized Exchange, EDS – External Data Sources, L2 – Layer 2 Solutions, ERC – Ethereum Request for Comments, CRRM – Computational Resource Regulation Mechanisms, CPP – Cross-chain Protocols

Figure 1. Conceptual model of the evolution of digital economy governance: a trajectory from fragility to antifragility using the example of Ethereum. *(Source: compiled by the authors based on a synthesis by Taleb (2012), Buterin (2014, 2016, 2017, 2020, 2021), Buterin et al., 2019, Wood (2014), Ethereum Foundation (2022), Antonopoulos & Wood (2018) and Ethereum ecosystem analysis)*

The presented conceptual model clearly demonstrates the evolution of management approaches in the digital economy using the Ethereum ecosystem as an example. This model not only reflects the current state of blockchain technologies, but also predicts their potential development in the context of broader economic transformation. The model is divided into three main zones corresponding to developmental stages: fragility, invulnerability and antifragility, which correlates with the concept proposed by Nassim Taleb (Taleb, 2012).

The left side of the model reflects the fragile centralized systems that characterize traditional finance and early cryptocurrency projects. These systems, although effective in certain conditions, are subject to significant risks and can be disrupted by severe external influences. Examples of such systems are centralized banks or the first generations of cryptocurrencies, which did not have sufficient flexibility and adaptability. In the context of Ethereum, this stage corresponds to the early stages of the project's development, when many aspects of the platform were not yet fully decentralized.

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The central part of the model illustrates the transition to greater sustainability through the introduction of innovative Ethereum technologies. This stage is characterized by the emergence of smart contracts, DApps and more advanced consensus mechanisms. Invulnerable systems are able to withstand and recover from external shocks, which significantly increases their reliability and efficiency in the long term. In the Ethereum ecosystem, this is evident in the development of DeFi, which demonstrates invulnerability to various market fluctuations and attacks (Chen & Bellavitis, 2020).

The right side of the model represents the antifragility zone, where advanced concepts such as DAO and adaptive protocols play a key role. Antifragile systems not only withstand stress and shock, but improve because of it. In the context of Ethereum, this can manifest itself in the form of self-learning protocols that automatically optimize their operation in response to changes in the network, or in the form of DAOs that are able to evolve and adapt to new conditions without centralized control. An example of such development is the transition of Ethereum to the Proof-of-Stake consensus mechanism, which not only improves the energy efficiency of the network, but also creates new incentives for ecosystem participants (Buterin, 2020; Ethereum Foundation, 2022).

It is important to note that the transition between such zones is not linear or predetermined. The Ethereum ecosystem demonstrates how technology can evolve from fragility to invulnerability to antifragility, but this process requires constant innovation, experimentation, and adaptation to new challenges. The model also emphasizes the importance of balancing stability and innovation, which is especially relevant in the context of a rapidly developing digital economy.

This conceptual model not only illustrates the evolution of Ethereum, but also provides an approach for analyzing other blockchain projects and digital economic systems. It allows you to assess how close a particular system is to the ideal of antifragility, and what steps need to be taken to increase its adaptability and invulnerability to external shocks. In a broader context, this model can serve as a guide for the development of new approaches to governance in the digital economy, where traditional centralized structures are increasingly shown to be ineffective in the face of global challenges. For a more detailed analysis of the transformation of management approaches in the context of evolution from fragility to antifragility, consider a comparative table of key characteristics of each stage (Table 6).

Table 6. Evolution of the digital economy governance model based on Ethereum: from fragility to antifragility. *(Source: compiled by the authors based on a summary Taleb (2012) and analysis of the Ethereum ecosystem)*

No.	Characteristic	Fragility (traditional model)	Invulnerability (possible current Ethereum model)	Antifragility (potential development of Ethereum)
1	Reaction to shocks	Destruction or significant damage	Stability and state conservation	Improvement and adaptation
2	Centralization	High	Low	Dynamic (adaptive decentralization)
3	Control	Hierarchical	Distributed	Evolutionary
4	Innovation	Slow, controlled	Fast but potentially chaotic	Directed, self-organizing
5	Safety	Depends on central authority	Cryptographic, distributed	Adaptive, self-reinforcing

The movement from fragility to antifragility in the management of the digital economy requires not only technological innovation, but also a fundamental rethinking of the principles of organization of economic systems. Ethereum, with its decentralized architecture and programmability, provides a platform for experimentation in this direction. However, it is important to note that achieving true antifragility remains an ideal rather than a current reality. Many aspects of the Ethereum ecosystem still show signs of fragility or, at best, invulnerability. Issues of scalability, energy efficiency and legal regulation pose serious challenges to the creation of an antifragile system for governing the digital economy.

However, a conceptual model based on Nassim Taleb's triad of Fragility-Invulnerability-Antifragility (Taleb, 2012) provides a useful framework for assessing the current status and development potential of blockchain technologies in the context of governing economic systems. She highlights the need not only for technological innovation, but also for new approaches to economic thinking and organization. In the context of entrepreneurship, the movement from fragility to antifragility in the Ethereum ecosystem requires new approaches to risk management and strategic planning. Entrepreneurs are being forced to develop more flexible business models that can not only withstand, but also benefit from the uncertainty and volatility of the crypto market. This stimulates the development of new competencies in the field of cryptoeconomics and decentralized governance, forming a new generation of digital business leaders.

DISCUSSION

Our research results demonstrate the multifaceted nature of Ethereum as a governance technology with the potential to transform existing economic and social structures. The interpretation of such results requires critical reflection in the context of current trends in the development of blockchain technologies and the digital economy.

The evolution from fragility to antifragility is reflected not only in the context of blockchain technologies, but also in the traditional financial sector. An example is a bank ranking system that takes into account factors of long-term and short-term stability (Khmarskyi & Pavlov, 2016). Developing this idea, a method has been developed for analyzing the structural and functional groups of banks, which makes it possible to assess the business models of banks and their risk profile based on the use of self-organizing Kohonen maps (Zarutska et al., 2022). Moreover, studies of the impact of non-financial information signals on stock market volatility (Pavlov et al., 2019) provide additional tools for analyzing the stability of financial systems. Such approaches can be adapted to analyze decentralized financial systems such as Ethereum, which will allow us to study in more detail the process of their evolution towards antifragility.

The concept of "governance through transactions", implemented in Ethereum, is an innovative approach to organizing economic relations. The use of smart contracts has the potential to reduce transaction costs and reduce the need for intermediaries, which is consistent with recent research by Yan Chen et al. (Chen et al., 2021), which highlights the potential of blockchain technologies to create more efficient and transparent governance systems. However, the process of institutionalizing the autonomy of cryptoassets reveals contradictions between the ideals of decentralization and practical implementation. Our observations are consistent with findings from recent work that analyzes the organizational aspects of value creation in blockchain systems (Zavolokina et al., 2024). The authors of this study emphasize that, despite the decentralized nature of the blockchain, in reality new forms of centralization and hierarchical structures often arise. This calls into question the fundamental principles underlying systems such as Ethereum.

Limitations of our study include the focus on a single platform (Ethereum), which may limit the generalizability of the results. In addition, the dynamic nature of technology and the regulatory environment may influence the long-term relevance of some of our findings. Despite these limitations, our study contributes to the understanding of the potential of blockchain technologies to transform governance in the digital economy, providing a basis for further research in this dynamic area.

CONCLUSIONS

The study allows us to draw a number of important conclusions about the role of the blockchain, in particular the Ethereum platform, as a new management technology in the context of the digital economy.

Firstly, we have argued that blockchain technologies, and Ethereum in particular, represent not just a technological innovation, but also a new paradigm for managing socio-economic relations. The "governance through transactions" established by blockchain is characterized by a focus on relations of exchange and association, an epistemological gap between the calculation and meaning of transactions, and the specific processes of forming and articulating these transactions.

Secondly, the study showed that the autonomy that is often attributed to blockchain systems is not an inherent property of them, but is the result of a complex process of institutionalization. This process involves the activities of various actors, from developers and entrepreneurs to users and regulators, as well as the formation of technical standards and social practices.

Third, we have demonstrated that Ethereum can be considered as an alternative proposal for governing the digital economy. This platform not only provides the technical infrastructure for decentralized applications, but also projects new forms of economic organization and transforms the concepts of ownership and management.

On the one hand, research into the Ethereum ecosystem reveals the potential of decentralized systems to create more open, transparent and inclusive forms of economic coordination. The ability to program economic relations through smart contracts opens up new horizons for experimenting with different models of organization and management. On the other hand, the study revealed a number of problems and limitations associated with the realization of such potential. Technical problems of scalability, difficulties of coordination in decentralized systems, risks of excessive algorithmization of social relations - all this creates serious challenges for the widespread implementation of blockchain technologies.

An important aspect of this study is the conceptual model we propose that describes the evolution of governance in the digital economy. Using the example of Ethereum, one can look at the evolution from fragile to more resilient and even

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antifragile systems, offering a fresh perspective on the analysis of decentralized structures. Integrating elements of the theory of complex systems, institutional economics and crypto-economics, the conceptual model not only reflects the current state of blockchain technologies but also outlines possible trajectories for their future development within the framework of large-scale economic transformations.

It is important to note that the institutionalization of crypto-asset autonomy does not occur in a vacuum but in complex interaction with existing institutions and regulatory frameworks. As the study showed, this process is often accompanied by the emergence of new forms of centralization and intermediation, which calls into question the original ideals of complete decentralization. In the context of broader debates about the future of the digital economy, Ethereum's experience provides valuable food for thought. It demonstrates both the possibilities and limitations of technological solutions in addressing fundamental questions of economic organization and social governance. Despite all the technical and conceptual difficulties, blockchain technologies and Ethereum in particular represent an important experiment in the field of socio-economic organization. Regardless of their ultimate success or failure, they are already forcing us to rethink fundamental concepts of trust, value and governance in the digital age.

Future research in this area could focus on more detailed case studies of Ethereum in various sectors of the economy, an analysis of the long-term consequences of the implementation of this technology, as well as a comparative analysis of different blockchain platforms and their governance approaches.

ADDITIONAL INFORMATION

AUTHOR CONTRIBUTIONS

All authors have contributed equally.

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The Authors declare that there is no conflict of interest.

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БЛОКЧЕЙН ЯК ТЕХНОЛОГІЯ УПРАВЛІННЯ: ІНСТИТУЦІОНАЛІЗАЦІЯ КРИПТОАКТИВІВ І ТРАНСФОРМАЦІЯ ПІДПРИЄМНИЦЬКИХ МОДЕЛЕЙ НА ПРИКЛАДІ ETHEREUM

Стрімкий розвиток блокчейн-технологій створює нову парадигму економічних відносин, що вимагає переосмислення традиційних підходів до управління та організації бізнесу. Актуальність дослідження Ethereum зумовлена його значним потенціалом для створення нових форм економічної координації, що виходять за межі наявних інституціональних структур. В умовах зростаючої складності глобальних економічних систем Ethereum пропонує унікальний підхід до вирішення проблем достовірності, прозорості й ефективності транзакцій. Метою роботи є обґрунтування ролі блокчейна як нової технології управління на прикладі платформи Ethereum, а також розкриття механізмів проєціювання уявної автономії в процесі її проєктування та інституціоналізації через діяльність різних акторів. Дослідження фокусується на формуванні альтернативних способів економічної координації підприємницьких структур і соціальної організації.

Виявлено ключові характеристики «управління через транзакції», реалізованого в Ethereum, зокрема фокус на відносинах обміну й асоціації, епістемологічний розрив між розрахунком і змістом транзакцій, а також особливі процеси формування і формулювання таких транзакцій. Проаналізовано процес інституціоналізації автономії криптоактивів, що демонструє складну взаємодію різних акторів, технологій і соціальних практик. Розроблено концептуальну модель еволюції управління цифровою економікою, що відображає траєкторію розвитку від крихкості до антикрихкості на прикладі Ethereum. Обґрунтовано трансформаційний потенціал Ethereum для наявних економічних і соціальних структур. Цю платформу розглядають як альтернативну пропозицію з управління цифровою економікою, здатну змінити фундаментальні принципи організації економічної діяльності. Виявлено також проблеми й обмеження, пов'язані з реалізацією децентралізованих систем, серед яких технічні виклики масштабованості, складнощі координації та ризики надмірної алгоритмізації соціальних відносин.

Ключові слова: блокчейн, Ethereum, криптоактиви, моделі підприємництва, децентралізоване управління, смарт-контракти, DeFi, антикрихкість, філософія інформації, цифрова онтологія

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