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Institutional Efficiency of DAOs in Scaling Digital Business Ecosystems

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Abstract. *The relevance of the study is determined by the growing role of decentralized autonomous organizations (DAOs) as an institutional basis for coordination and management in scalable digital business ecosystems in conditions of limited effectiveness of traditional hierarchical models.*

The purpose of the article is to provide a theoretical justification for the institutional effectiveness of DAOs and to identify the main mechanisms of their influence on the processes of coordination, distribution of responsibility, and decision-making in digital ecosystems.

The methodological basis of the study is formed by the provisions of institutional economics, transaction cost theory, and collective action theory. The research uses methods of system analysis, theoretical generalization, comparative analysis, and institutional modeling.

As a result of the research, the essence of DAOs as a new type of institutional construct in which formal and informal rules are integrated directly into the mechanism of coordination of economic agents has been clarified. It has been found



that algorithmic enforcement, implemented through smart contracts, contributes to a reduction in transaction costs associated with the fulfillment and control of obligations, while strengthening institutional constraints. The main mechanisms of DAO's influence on coordination have been identified, in particular procedural and asynchronous interaction, tokenized collective decision-making, and distributed responsibility. It has been found that the effectiveness of DAOs critically depends on the interaction between formal institutions and informal factors such as trust, reputation, and the activity of the community core. A generalized analytical model has been developed that demonstrates the relationship between DAO institutional mechanisms, their effects, and potential risks in the context of scaling digital ecosystems.

The conclusions indicate that DAOs perform the functions of institutional coordination and reduction of transaction costs in digital business ecosystems through the algorithmization of formal rules and the use of smart contracts as a mechanism for ensuring compliance with norms.

Keywords: *transaction costs, technological tools, coordination processes, distribution of responsibility, smart contracts.*

Інституційна ефективність DAO в масштабуванні цифрових бізнес-екосистем

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Анотація. *Актуальність дослідження зумовлена зростанням ролі децентралізованих автономних організацій (англ. Decentralized Autonomous Organization, далі – DAO) як інституційної основи координації та управління*



в масштабованих цифрових бізнес-екосистемах в умовах обмеженої ефективності традиційних ієрархічних моделей.

Метою статті є теоретичне обґрунтування інституційної ефективності DAO та ідентифікація основних механізмів їхнього впливу на процеси координації, розподілу відповідальності й прийняття рішень у цифрових екосистемах.

Методологічну основу дослідження становлять положення інституційної економіки, теорії трансакційних витрат і теорії колективної дії. У процесі дослідження використано методи системного аналізу, теоретичного узагальнення, порівняльного аналізу та інституційного моделювання.

У результаті дослідження уточнено сутність DAO як інституційної конструкції нового типу, у якій формальні та неформальні правила інтегровані безпосередньо в механізм координації економічних агентів. З'ясовано, що алгоритмізований примус, реалізований через смартконтракти, сприяє скороченню трансакційних витрат, пов'язаних із виконанням і контролем зобов'язань, водночас посилюючи інституційні обмеження. Ідентифіковано основні механізми впливу DAO на координацію, зокрема процедурну та асинхронну взаємодію, токенізоване колективне прийняття рішень і розподілену відповідальність. Виявлено, що ефективність DAO критично залежить від взаємодії формальних інститутів із неформальними чинниками – довірою, репутацією та активністю ядра спільноти. Отримано узагальнену аналітичну модель, яка демонструє зв'язок між інституційними механізмами DAO, їхніми ефектами та потенційними ризиками в умовах масштабування цифрових екосистем.

У висновках зазначено, що DAO виконують функції інституційної координації та зниження трансакційних витрат у цифрових бізнес-



екосистемах завдяки алгоритмізації формальних правил і використанню смартконтрактів як механізму забезпечення виконання норм.

Ключові слова: *транзакційні витрати, технологічний інструментарій, процеси координації, розподіл відповідальності, смартконтракти.*

Introduction. The rapid digitalization of the economy has fundamentally transformed perceptions of organizational forms of business, mechanisms for coordinating market participants, and instruments for creating economic value. In this context, DAOs are moving beyond experimental practices of blockchain communities and are increasingly emerging as institutional entities capable of governing complex digital business ecosystems. It is precisely this evolution in the role of DAOs that determines the heightened relevance of studying their institutional effectiveness.

Traditional hierarchical governance models that dominated the industrial and postindustrial economy demonstrate limited adaptability in an environment of rapid technological change, global networked interaction, and a growing number of independent ecosystem participants. Digital business ecosystems formed around platforms, protocols, and open innovation require flexible coordination mechanisms that can scale without a proportional increase in transaction costs. Within these transformations, DAOs offer an alternative logic of institutional organization based on smart contracts, distributed decision making, and transparent participation rules.

Thus, the relevance of this study is determined by a combination of factors, including the evolution of digital business ecosystems, the growing role of decentralized governance forms, and the presence of significant theoretical and applied gaps in understanding the institutional effectiveness of DAOs. The proposed scholarly analysis aims to address these gaps through a systematic interpretation of DAOs not only as a technological tool, but as an institutional entity that shapes a new logic for scaling digital business.



Literature Review. Contemporary scholarly discourse on decentralized autonomous organizations is shaped at the intersection of corporate governance, institutional economics, and digital ecosystem studies. One of the earliest researchers to provide a systematic conceptualization of DAOs as a governance phenomenon is W. A. Kaal. The author demonstrates that the internal governance mechanisms of DAOs cannot be examined in isolation from the external legal environment. The scholar argues that the formal autonomy of DAOs encounters constraints imposed by traditional institutions, particularly corporate and contract law, which generates tension between algorithmic rules and legal accountability [1].

A more conceptual perspective on DAOs is offered by S. Hassan and P. De Filippi, who consider them a new form of collective action organization in the digital environment. The authors find that DAOs transform traditional coordination mechanisms by replacing hierarchical control with procedural rules embedded in code. A key outcome of their study is the assertion of the hybrid nature of DAOs, in which formal algorithmic rules continuously interact with informal social norms [2]. An integrative model that combines technological, organizational, and social dimensions of DAO functioning is proposed by C. Santana and L. Albareda. The researchers establish that DAOs are not a homogeneous phenomenon, but differ in community structure, governance models, and funding mechanisms [3].

The operational dimension of DAOs is examined in detail by X. Zhao and coauthors, who demonstrate that DAOs can ensure effective task management provided that roles and incentives are clearly formalized. The authors show that algorithmic task allocation mechanisms reduce coordination costs and enhance the transparency of participants' contributions [4].

An empirical understanding of the internal dynamics of DAOs is presented by N. Augustin and colleagues, who demonstrate that actual governance practices often diverge from the declared principles of decentralization. The researchers find



that an active core of the community plays a leading role in decision making, while the majority of participants remain passive [5].

A systematic review of contemporary approaches to DAO governance is conducted by J. Han and coauthors, who synthesize trends related to vote concentration and the emergence of new forms of delegation of authority. The authors conclude that tokenized voting, despite formal equality, often results in an asymmetric distribution of influence. At the same time, they emphasize the lack of studies that integrate governance analysis with institutional effectiveness in the long term [6]. An institutional economic perspective on DAOs is further developed by S. Davidson, who, within the framework of transaction cost theory, demonstrates that DAOs reduce contract execution costs while simultaneously generating new costs associated with institutional design and adaptation [7].

A critical perspective on the actual behavior of DAO participants is offered by A. Alawadi and colleagues, who identify discrepancies between the declared stewardship model and actual agency practices. The researchers demonstrate that even in decentralized structures, participants seek to strengthen their own influence, which may contradict the achievement of collective goals [8]. The problem of power concentration is quantitatively confirmed by R. Fritsch and co-authors, who established that the actual distribution of votes in DAOs is significantly more asymmetric than formal governance models assume. Their data indicate the dominance of a limited group of participants in decision-making processes, which has direct implications for institutional effectiveness [9]. Additional context on the digital transformation of institutions is provided by O. Hetmanenko and B. Tyvodar, who argue that digitalization can increase transparency and reduce corruption risks, but only under conditions of appropriate institutional design [10]. Although their research does not focus directly on DAOs, its findings emphasize the importance of combining technological tools with institutional accountability mechanisms.



Identification of Previously Unresolved Aspects of the General Problem.

The synthesis of prior research results makes it possible to identify several scholarly gaps. First, in most studies DAOs are examined either from a governance perspective or from a technical and organizational perspective, leaving aside their role as institutions at the ecosystem level. Second, the interaction between formal and informal DAO institutions in the processes of scaling digital business ecosystems remains insufficiently explored. Addressing these gaps constitutes the scientific focus of this study.

Formulation of the Article Objectives and Research Tasks. The purpose of the article is to substantiate the institutional effectiveness of DAOs as a governance form under conditions of scaling digital business ecosystems.

To achieve this purpose, the following tasks are defined:

- 1) to clarify the essence and key characteristics of DAOs from the perspective of institutional economics;
- 2) to identify the main mechanisms through which DAOs influence coordination processes, the allocation of responsibility, and decision making in digital ecosystems;
- 3) to outline potential directions for enhancing the institutional capacity of DAOs to ensure the sustainable development of digital business ecosystems.

Research Results. The study of DAOs requires a systemic approach that integrates technological and institutional aspects, since their effectiveness is determined not only by code, but also by the rules and norms governing participant interaction. From the perspective of institutional economics, DAOs should be interpreted not as a set of smart contracts or software modules, but as a complex system of rules, norms, and enforcement mechanisms that structure the interaction of economic agents in a digital environment [1].

Institutional economics traditionally views institutions as constraints created by humans to reduce uncertainty in interactions. In this sense, DAOs perform the



same basic functions as classical institutions: they coordinate the actions of participants and establish predictable behavioral frameworks. The difference lies not in functional purpose, but in the mode of implementation of these functions. Whereas in traditional organizations rule compliance is ensured through hierarchy, contract law, or social sanctions, in DAOs enforcement is increasingly embedded directly in algorithmic execution [2, p. 7].

From a historical perspective, the idea of decentralized organizational forms is not new to organizational theory. Since the mid twentieth century, scholarly literature has examined various types of decentralized structures, network governance forms, and self managing systems [3]. However, the contemporary understanding of DAOs emerged much later, at the intersection of blockchain technologies, cryptoeconomics, and debates on alternative models of corporate governance. Initially, these ideas were embodied in the concept of decentralized autonomous corporations, defined as self executing structures without direct human intervention. Over time, the focus shifted from the corporation as a legal formation to the organization as an institutional system.

Comparing DAOs with firms, platforms, or networks makes it possible to more clearly delineate their institutional specificity. Like a firm, a DAO seeks to reduce transaction costs. Similar to digital platforms, it facilitates interaction among a multitude of independent participants based on standardized rules. At the same time, unlike classical networks, a DAO formalizes a significant share of these rules in the form of code that is executed automatically. Thus, a DAO occupies an intermediate position between hierarchy and network, integrating elements of both models without fully identifying with either.

Particular attention should be paid to the concept of autonomy, which is often interpreted too literally. In the context of DAOs, autonomy does not imply the absence of institutions or social constraints. On the contrary, it refers to their radical formalization and algorithmization [4, p. 651]. Rules that in traditional organizations



exist in the form of charters, internal regulations, or informal agreements are transformed in DAOs into program code. This transformation alters the nature of institutional enforcement: it becomes not reactive, but preventive, since rule violations are often technically impossible.

At the same time, it would be a mistake to view DAOs as entirely humanless systems. Alongside the formal institutions embedded in code, informal rules also operate, including participation norms, reputation mechanisms, and informal leadership. It is precisely the interaction between these algorithmized institutions and informal practices that determines the actual effectiveness of DAOs as an institutional arrangement. In this sense, DAOs do not eliminate institutions, but rather propose a new way of designing and enforcing them.

Thus, DAOs should be considered a new type of institutional construct in which the rules governing the behavior of economic agents are integrated directly into the coordination mechanism. This approach makes it possible to explain both the potential of DAOs to reduce transaction costs and scale digital business ecosystems, and the limitations associated with the rigidity of formal rules and dependence on the social dynamics of communities.

The most visible institutional dimension of DAOs is their formal rules, codified in the form of smart contracts. These rules often become the starting point for the analysis of DAOs, as they serve as the structural foundation upon which the entire system of interactions is built. However, from an institutional perspective, it is not the technical implementation of smart contracts that is most important, but their capacity to perform economic functions and structure participant interaction. In DAOs, smart contracts effectively replace traditional contracts, internal regulations, and a substantial share of managerial procedures characteristic of hierarchical organizations. They specify the conditions of participation, the procedures for resource allocation, the rules for decision making, as well as the consequences of certain actions or inaction by participants [5]. Unlike classical



contracts, whose enforcement often depends on external coercion or judicial mechanisms, smart contracts implement the principle of automatic execution. The formal and informal institutions of DAOs are presented in Table 1.

Table 1

Formal and informal DAO institutions: institutional analysis

Formal DAO institutions	Informal DAO institutions	Analytical commentary
Type of rules		
Algorithmic smart contracts that define rights, obligations, and procedures	Social norms, behavioral expectations, unwritten agreements	Formal rules define permissible actions, but do not cover the full range of social interactions; it is informal institutions that fill the institutional gaps that cannot be fully formalized without losing flexibility
Enforcement mechanism		
Automatic execution through code without external control	Reputational sanctions, removal from informal networks	Transferring enforcement to code reduces control costs, but does not eliminate the need for social enforcement where participant behavior cannot be fully algorithmized
Flexibility of change		
Low; changes are only possible through formalized procedures	High; rules evolve along with community practices	Institutional stability is ensured by code, but the adaptability of the system is determined by the speed of transformation of informal norms
Transparency		



Formal DAO institutions	Informal DAO institutions	Analytical commentary
Full public access to code and transactions	Partial, contextual, dependent on communication	Transparency of formal rules reduces information asymmetry, but does not eliminate inequality in the ability to interpret and influence institutional processes
Distribution of power		
Formally decentralized through tokenized voting	Effectively concentrated around an active and competent core	DAOs transform but do not eliminate power asymmetry: it shifts from hierarchy to ownership of resources, knowledge, and social capital
Incentives for participation		
Financial incentives, tokens, share in the treasury	Reputation, identity, ideological engagement	Sustainable participation arises only when material and non-material incentives are combined; the predominance of one over the other weakens long-term institutional effectiveness

Source: author's own development

As shown in Table 1, formal and informal DAO institutions implement different mechanisms of influence on participants and processes. This fundamentally changes the nature of institutional coercion: whereas in traditional organizations compliance with rules is ensured through managerial hierarchy, control, and sanctions, in DAOs the coercive function is transferred directly to code. Participants not only know the rules; they are technically constrained in their ability to violate them. In this sense, formal DAO institutions are rigid in nature [6]. At the same time,



this rigidity is offset by a high level of transparency, as the rules are open, publicly verifiable, and the same for everyone.

From an institutional point of view, such a model creates the potential for reducing transaction costs. There is no longer a need for intermediaries, auditors, or a significant part of control functions. The costs of ensuring compliance with agreements are minimized, since a significant part of the risks of opportunistic behavior are neutralized at the level of institutional design. However, this effect is not universal [10, p. 319]. Rigidly coded rules reduce the flexibility of adaptation, and errors in the design of smart contracts can have far-reaching consequences.

The procedure for changing formal rules deserves special attention. In a DAO, it is usually not an administrative act of a single entity. On the contrary, changing the rules requires collective consent, implemented through governance mechanisms. This means that the formal institutions of a DAO are both stable and potentially evolutionary, but the speed and direction of this evolution are determined by the structure of participation and the distribution of influence within the community. Thus, the formal institutions of a DAO can be viewed as algorithmic rules in which institutional coercion is not eliminated but transformed. It ceases to be personified and becomes procedural, embedded in the coordination mechanism itself.

At the same time, despite the algorithmization of a significant part of the rules, DAOs remain socio-economic systems whose effectiveness depends heavily on informal institutions. It is these institutions that fill formal mechanisms with real content. Trust, reputation, and social capital are as important in DAOs as they are in traditional communities and network organizations. Participants make decisions not only on the basis of formal incentives, but also taking into account the reputation of the authors of proposals, informal norms of participation, and expectations regarding the behavior of others. In this context, DAOs demonstrate continuity with open software communities, in which formal structure is often combined with deeply rooted social norms.



The practice of DAO functioning shows that the activity of the core community is crucial. A small group of participants usually initiates proposals, sets the agenda, and possesses critical knowledge about the technical or economic architecture of the organization. Formally, these participants may have equal rights with others, but informally, their influence is much greater. Thus, even in decentralized structures, there is an asymmetry of influence, caused not by hierarchy, but by the concentration of competence, time, and motivation.

Participation norms and voting culture are also important informal institutions. The frequency of participation in voting, the willingness to discuss proposals, and tolerance for conflict all directly affect the institutional effectiveness of a DAO. Formal governance mechanisms may be well designed, but without an active community they become empty procedures [11]. In this sense, DAOs cannot be reduced to a set of smart contracts or voting mechanisms. Their real viability is determined by a combination of algorithmic rules and the social dynamics of the community. It is the interaction of formal and informal institutions that explains why organizations with similar technical architectures demonstrate significantly different outcomes. Thus, DAOs emerge not as purely technical entities, but as socioeconomic systems in which code and community complement each other. Ignoring this dual nature leads to erroneous conclusions about their institutional effectiveness and scalability potential.

In the context of digital business ecosystems, DAOs perform a broader function: they form specific coordination mechanisms among independent actors who are not bound by either hierarchy or stable contractual relationships [12, p. 17]. Through these mechanisms, decentralized autonomous organizations influence how decisions are made, how responsibility is distributed, and how actions are coordinated under conditions of high complexity and uncertainty (Table 2).

**Table 2**

DAO mechanisms for influencing coordination and management in digital ecosystems

DAO mechanism	Institutional effect
Procedural coordination through coded rules	Reduced transaction costs of coordination and increased predictability of interactions between autonomous participants
Asynchronous interaction between participants	Scaling coordination without increasing management costs
Algorithmic enforcement of rules	Reduction of opportunistic behavior and control costs
Tokenized voting	Formalization of collective choice and increased transparency of decision-making
Combined governance	Combining formal stability with discursive flexibility
Distributed responsibility of participants	Promoting engagement and encouraging participation
Economic incentives (tokens, rewards)	Increasing engagement and supporting community activity

Source: author's own development

As we can see from Table 2, DAOs implement a number of coordination and management mechanisms, among which procedural coordination, which replaces traditional management chains, is of primary importance. In DAOs, coordination of actions does not take place through individual orders or vertical commands, but through predefined rules of interaction. These rules set the format for proposals, the order in which they are discussed, and the conditions for their implementation, thereby reducing the need for constant managerial intervention [13]. Coordination



becomes asynchronous: participants do not interact directly with each other, but indirectly through common procedures. This allows participation to be scaled without a proportional increase in management costs.

At the same time, this form of coordination changes the very logic of responsibility distribution. In a DAO, responsibility is rarely personified in a specific position or role. It is distributed among participants according to their involvement in specific processes and is also recorded in smart contracts in the form of conditions for the performance or non-performance of certain actions [14]. As a result, responsibility becomes procedural: what matters is not so much the participant's intention as their compliance with the set rules. This approach promotes engagement in the ecosystem, but at the same time complicates the mechanisms for holding people accountable in the event of collective or strategic mistakes.

The most controversial mechanism is the specific decision-making model embedded in the DAO management system. Formally, it is based on the principles of collective choice, where voting rights are linked to the ownership of tokens or other formalized indicators of participation. Decision-making takes place through a combination of on-chain voting and off-chain discussions, creating a hybrid institutional model [14]. On the one hand, this model increases the transparency and predictability of the process. On the other hand, it does not eliminate but rather transforms the classic problems of collective action, in particular the concentration of influence and the passivity of the majority of participants.

At the level of digital business ecosystems, DAOs act as an institutional layer that combines technological infrastructure with the behavior of economic agents. They do not necessarily control participants directly, but they do define the framework within which interaction takes place [15]. Thanks to this, DAOs are able to coordinate the activities of a large number of autonomous actors without formally including them in a single organization. Coordination is achieved not through



subordination, but through participation in jointly constructed institutional mechanisms.

Thus, the impact of DAOs on coordination, distribution of responsibility, and decision-making lies not in the elimination of institutional constraints, but in their reconfiguration. DAOs change the way collective action is organized, shifting the emphasis from hierarchy to procedures, from status to participation, from personalized responsibility to algorithmic rules. It is these mechanisms that determine their potential and, at the same time, define the limits of effectiveness in scaling digital business ecosystems.

Conclusions. The article provides a comprehensive study of the institutional effectiveness of decentralized autonomous organizations in the context of scaling digital business ecosystems. The results obtained allow us to expand the theoretical understanding of DAOs as a new type of institutional construct and to clarify the mechanisms of their influence on coordination, distribution of responsibility, and decision-making in a decentralized digital environment.

Based on institutional analysis, it has been established that DAOs perform the basic functions of classical economic institutions, in particular reducing uncertainty, coordinating actions, and limiting opportunistic behavior, through the algorithmization of formal rules. It has been proven that smart contracts are not only a technical tool but also a mechanism of institutional coercion that transfers the function of ensuring compliance with norms from the organizational hierarchy directly to the code. This reduces the transaction costs of enforcement and control while increasing the rigidity and complexity of rule adaptation.

The study identified the main mechanisms of DAO influence on coordination processes in digital ecosystems, in particular procedural and asynchronous coordination, tokenized collective choice mechanisms, distributed responsibility, and combined management models. It has been shown that these mechanisms allow for scaling interactions between autonomous participants without a proportional



increase in management costs, but at the same time create new risks associated with concentration of influence, fragmentation of responsibility, and reduced decision-making efficiency.

Prospects for further research may be related to empirical testing of the identified mechanisms based on a comparative analysis of specific DAOs, as well as a quantitative assessment of the impact of different governance models on the long-term efficiency and sustainability of digital business ecosystems.

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