

# Institutional modeling and management of the firm's ecosystem

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**Abstract.** By the early 20s of this century, it became clear that the network paradigm of inter-firm relations does not describe the entire landscape of business interactions. The introduction of digital technologies stimulated business development taking into account not only economic partners, consumers, suppliers and competitors, but also taking into account the influence of public organizations, authorities and social media. The paradigm of ecosystem analysis of the economy began to develop, the first works of which appeared at the end of the twentieth century. The purpose of this study is to develop an institutional model and principles for managing the firm's ecosystem. The theoretical basis of the research is the authors' model of the potential of digitalization of the company's ecosystem. The article analyzes and criticizes previous studies, which demonstrated the relevance of formulating the problem of developing the formalized potential of digitalization of the firm's ecosystem. Based on the authors' development on the representation of ecosystem actors in the form of stakeholders, the main components of the external space of the company are identified: stakeholders, company resources and end-to-end digital technologies. The main factors forming the potential of digitalization of the company's ecosystem are highlighted. Ecosystem stakeholders are divided into representatives of business, government, consumers, education and science, and mass media. The company's resources are material, labor, financial and information resources. Digital technologies: artificial intelligence, additive technologies, blockchain, the Internet of Things, robotics, social networks, virtual reality. Various directions of application of the formalized potential of digitalization of the company's ecosystem are presented: the possibility of assessing the use of potential in various directions; assessment of the impact of various components of the firm's ecosystem on the development of its other elements; development of a general analytical model of potential; assessment of threshold values of factors for the development of the potential of digitalization of the firm's ecosystem; a tool for developing a strategy for the firm's ecosystem.

## 1 Introduction

The rapid development of digital technologies has turned our ideas about business interactions upside down. Two decades ago, relations between firms were described in a

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fairly complete way within the framework of network relations, the pinnacle of modeling of which was the assessment of transaction costs of hybrid organizations and the corresponding awarding of the Nobel Prize in Economics in 2009 to O. Williamson and E. Ostrom for the development of the theory of economic organization, and in fact for the possibility of evaluating network structures. By the early 20s of this century, it became clear that the network paradigm of inter-firm relations does not describe the entire landscape of business interactions. The introduction of digital technologies stimulated business development taking into account not only economic partners, consumers, suppliers and competitors, but also taking into account the influence of public organizations, authorities and social media. The paradigm of ecosystem analysis of the economy began to develop, the first works of which appeared at the end of the twentieth century.

The ancestor of the term "ecosystem" in relation to business is considered to be J. Moore, who defined an ecosystem as "an economic community supported by a basis of interacting organizations and individuals" (Moore, 1997). The analysis of firm ecosystems involves an assessment of all individuals and organizations interested in relations with these firms. Since the relationship of a firm with elements of the ecosystem is not always characterized by economic content, the analysis of such relationships is a complex problem, often solved by interdisciplinary methods.

In the world databases, publications on economic ecosystems are increasing exponentially. This is due to the increased interest in the new paradigm of the analysis of inter-firm relations. At the same time, many studies have shown that the company's ecosystem is the basis for the development and implementation of innovations. But there are no generalizing studies on the problem of modeling the company's ecosystem in the domestic scientific literature yet.

The development of digital technologies is changing the landscape of economic activity and business activity management procedures. One of the most important trends in the analysis of economic activity in the last two decades has been the transition from the paradigm of assessing the company's network interactions with suppliers, consumers and competitors to the paradigm of ecosystem analysis of economic relations.

The firm's ecosystem refers to the space of economic relations not only with suppliers, consumers and competitors, but also with authorities, mass media, universities and scientific organizations – all structures that somehow influence the economic activity of the firm. The importance of ecosystem assessment is increasing due to the use of new digital technologies, as the introduction of mobile communications, artificial intelligence, blockchain technologies, the Internet of Things, virtual and augmented reality have dramatically changed the possibilities of information exchange between ecosystem actors and the ability to make quick management decisions.

Currently, there is a surge of publications in the world scientific literature on the assessment of the consequences of the introduction of digital technologies into the space of economic activity of firms. At the same time, the apparatus for assessing the development of digitalization of the firm's ecosystem has not yet been formulated. One of the possible methods of creating such a device is an approach related to the development of the potential of digitalization.

Hence, the purpose of this study is to develop an institutional model and principles for managing the firm's ecosystem. The institutional model is presented in the form of the potential for digitalization of the firm's ecosystem, which means the cumulative ability of the firm to introduce digital technologies based on the optimal use of available resources to create the best interaction with stakeholders of the firm's ecosystem, ensuring the economic activity of the firm.

The algorithm of this study included the following stages: criticism of previous studies with the formulation of the problem of creating a formalized apparatus for assessing the

digitalization of the firm's ecosystem, the development of the authors' idea of the formalized structure of the company's digitalization potential, the definition of the directions of application of this potential.

## **2 Problems of ecosystem digitalization assessment**

Modern ecosystems of firms, developed in the era of the formation of a digital society, inevitably turn into truly digital ecosystems. In this case, interaction with consumers acts as a socio-technical phenomenon that arises as a result of consumer actions using digital technologies, where action and technology are an integral part of the practice of interaction and are subject to continuous and mutually recursive changes. Consumers participate in the digital ecosystem through actions with physical devices, digital tactile sensations and digital platforms. The digital essence of the ecosystem generates new types of interaction practices (Morgan-Thomas et al., 2020).

At the same time, platforms are necessary to expand the possibilities of connection and transformation of business networks into digital ecosystems (Aulkemeier et al., 2019). Digital platforms are a ubiquitous phenomenon that challenges manufacturers and consumers by changing the way we consume and deliver digital products and services. While traditional firms create value within a company or supply chain, digital platforms use an ecosystem of autonomous agents to co-create value (Hein et al., 2020). It is determined that organizations with a high degree of digitalization can potentially grow faster in the market. They can do this by providing a digital platform and creating an ecosystem of additional third-party developers (Yonatan, 2017).

Manufacturers are switching between competitive and cooperative strategies in response to the emergence of digital platforms. Such a process is characterized by three successive phases: selective cooperation, allied competition and selective competition. Switching between different multi-level strategies covering market segments, products and technological components is a viable solution for existing manufacturers adapting to platforms (Cuzzolino et al., 2021). In this case, the organization of platforms is considered as a combination of resources to create collective value and their expansion can follow the logic of externalization. The management of ecosystems focused on digital platforms provides added value in comparison with the management of network corporations (Li et al., 2019).

The digital ecosystem is the next generation of the Internet and network applications, promising a new world of distributed and open systems that can interact, self-organize, evolve and adapt. Such ecosystems go beyond traditional collaboration environments, such as client-server, peer-to-peer and hybrid models (for example, web services), turning into a self-organizing, evolving interactive environment (Lippert, Cloutier, 2021). Differences between and within countries lead to differences in the involvement of digital consumers, especially in the graying of clicks and information exchange. Differences in national values affect interaction with digital technologies and cultural differences within a country soften these relations (Thompson, Brouters, 2021).

How can the digitalization of the economic space be assessed in relation to the ecosystem of the firm?

If we apply the index assessment methodology, then to assess the development of digitalization, we can use a matrix approach with an assessment of two indices: the index of activity of subjects of digitalization and the index of digitalization conditions. This approach is applicable to the analysis of digital ecosystems at the regional level (Stepanova et al., 2019). However, this approach is not applicable at the firm level, since there are no subjects of digitalization here, but there are actors whose evaluation of digitalization is a separate research task.

A well-known tool for assessing the company's ecosystem is a circular model of the external space of the company, which allows mapping elements of this space (Talmir et al., 2020). A similar mapping method can also be used to assess interactions between data sources and vertical and horizontal integration domains in ecosystem platform relationships (Lee et al., 2020). At the same time, this approach does not reflect the dynamics of the development of ecosystem elements and cannot be applied when developing an ecosystem development strategy.

The method of configuration analysis can be used to assess the ecosystems. For example, for such an object as smart cities, the configuration structure of the ecosystem can be assessed using five key dimensions that are displayed in five organizational structures: actors, urban subsystems, levels of activity, rules of activity of actors at various levels of activity, institutional support for this activity (Pierce et al., 2017). For such objects of the economy SWOT-analysis can also be applied in combination with the process of analytical hierarchy. This analysis is used as a quantitative strategic planning tool (Yuan et al., 2020). But these methods do not contain an assessment of the introduction of advanced technologies and cannot be used to analyze the level of digitalization of the company's ecosystem.

The introduction of digital technologies into ecosystems can be analyzed based on an assessment of the key characteristics of a growing business and the ability to occupy leading positions: joint business creation through the integration of resources and the exchange of services is preferable to meet the needs of the market; platform is important in creating the knowledge for the integration of resources and the exchange of services; intelligent services combine the ecosystem and the platform and create a result that solves a specific problem (Pulkkinen et al., 2019). Unfortunately, this method has not received a formalized representation.

Note that fragmented ecosystem management reduces the scale of savings and leads to the incompatibility of interdisciplinary data that limit spatial intelligence and the benefits of open data (Kitchin, Moore-Cherry, 2020).

Thus, the analysis of studies demonstrates the need to solve the problem of developing a formalized apparatus for evaluating the digitalization of the company's ecosystem.

### **3 Materials and methods**

Earlier we formulated the principle of connectivity of the elements of the system. The idea of assessing the network potential of the ecosystem core is put forward. The principle of systematic existence of an ecosystem is proposed, which consists in the fact that the stability of an economic ecosystem is ensured by the presence of systemic relations between its elements. The principle of reciprocity of ecosystem elements has been developed, demonstrating that the functioning of an ecosystem is ensured by mutual connections between its elements. The practical implementation of the principle is possible within the framework of the idea of stakeholder modeling of the ecosystem. The idea of transactional optimality of the configuration of elements of the economic ecosystem is put forward.

The object of this study is the digital ecosystem of the company, the subject of the study is economic relations for the development of the digital ecosystem of the company. The research method is logical system analysis. The information base was the results of research published in the world database WoS Core Collection for 2015-2021.

To develop a formalized representation of the potential of ecosystem digitalization, the firms used the authors' work on integrated differentiation of ecosystem actors in the form of stakeholders (Popov, 2021).

## **4 The structure of the potential of digitalization of the ecosystem of firms**

The most important component of the digitalization potential of the company's ecosystem is the assessment of relationships with stakeholders. For example, to assess the development of digital economy objects, the quadrupole spiral analysis method is successfully used, which is based on the evolution of four stakeholders: education and science, public sector management, private business sector activities and civil society participation (Paskaleva et al., 2021).

Previous research shows that the most important stakeholders of the firm's ecosystem are representatives of business, government, education and science, mass media, consumers (Popov et al., 2021).

By obtaining government contracts, firms gain access to relevant innovations, increase their knowledge and capabilities, and explore possible ways to develop in the market. Public organizations use grants to connect with innovative firms and share their experience and new ideas, which contributes to the development of ecosystems (Selviaridis, 2020). Especially at the growth stage, the ecosystem focuses on establishing external relations with other parties, such as competitors and suppliers. At this stage, management elements, such as a collaborative creative strategy and a dedicated organization for promotion, become important because these elements facilitate communication with business organizations (Ooms et al., 2020).

The influence of the authorities on the development of the ecosystem is primarily due to the establishment of formal institutions and informal conditions (corruption, extortion, informal trade), which have a significant impact on the increase in the number of innovations of the enterprise (Guerrero, Urbano, 2020). Sustainable ecosystems require top-down exploration of policy alternatives together with bottom-up knowledge-based entrepreneurship to promote their products (Gifford et al., 2020). The authorities coordinate data collection initiatives from an organizational perspective. Three elements of coordination in the ecosystems, namely openness, dissemination and a common vision, are identified as the main factors contributing to the implementation of initiatives in the development of ecosystems (Gupta et al., 2020).

Consumers influence the development of the company's ecosystem, forming the demand. At the same time, the quality of demand supports innovation in the production segment, which has led to the fact that receiving more complex feedback on demand is a potentially powerful incentive to promote digital technologies in the ecosystem (Giovanini et al., 2020).

Education and science influence the formation of the ecosystem by introducing new innovative knowledge. An entrepreneurial ecosystem with an emphasis on the creation of new firms can move to a business ecosystem with a primary focus on the internal commercialization of knowledge. This leads to the growth and maturity of the firm's entrepreneurial ecosystems (Cantner et al., 2021). With the help of modern digital technologies, the objects of the digital economy strive to optimize their work and services. In this case, mass media contribute to strengthening the governance and sustainability of ecosystem development initiatives (Hamalainen, 2020).

The potential of digitalization of the ecosystem is determined by the resources – material, labor, financial and information. Material resources are a physical infrastructure that allows actors and stakeholders of the ecosystem to ensure close interaction (Stam, Ven, 2021).

Human resources are becoming important. As a result of efforts to digitally transform ecosystems, the huge demand for digital skills has led to a shortage of digital talent. Universities should understand the needs of employers for digital opportunities to train graduates who are able to work in a digital format. Authorities should engage digital technology professionals to simplify and digitize their services and operations. Firms must

attract digital talent to succeed in digital transformation and gain a competitive advantage (Karaboga et al., 2021).

The financial resources mean that there are opportunities to invest in those activities that have not yet received the necessary financial resources (Stam, Ven, 2021). Information resources are the basis for the functioning of the company's ecosystem. It is possible to evaluate them through the stages: vision and concepts - digital ecosystem - dissemination and events (Elberzhager et al., 2021).

The main component of the ecosystem digitalization potential is digital technologies, that (in addition to big data) include: artificial intelligence, additive technologies, blockchain, IoT, robotics, social networks and VR/AR technologies.

Thanks to the huge amounts of data, the management of firms have the ability to monitor and manage infrastructure in real time (Engin et al., 2020). Additive technologies due to 3D printing allow solving innovative structural problems (Beltagui et al., 2020).

The value of blockchain can be represented in four directions: the impact of the network on trust in society, authorities and organizations; empowering individuals and strengthening the economy; liquid economy; shared economy (Kundu, 2019). IoT, in turn, reconfigures connections between users, suppliers and infrastructures, which smooths out structural uncertainty and ensures reliable interactions (Chambers, Evans, 2020).

The objects of the digital economy are becoming experimental platforms for new forms of robotics and automation technologies. Robotics and automation systems are superimposed on networks, expanding the capabilities of human resources and infrastructure networks (Macrorie et al., 2021).

One of the important derivatives of digital technologies is the means of communication, known as social network services, which provide additional functionality to objects of the digital economy (Hajikhani, 2020). The literature on digital technologies includes numerous studies on the role of social networks in the development of communities, including examples of innovative mobile applications that increase literacy and access to medical, banking and other services. Sustainable development requires not only scientific and technical means, but also support from social networks (Naymaka et al., 2020). VR, in turn, makes it possible to form digital counterparts for making informed management decisions (Nochta et al., 2021).

Thus, the analysis of various aspects of the ecosystem digitalization potential allows us to present a formalized representation of this potential in the form of a cube, the sides of which are stakeholders, digital technologies and resources. Stakeholders are divided into representatives of business, government, consumers, education and science, the media. The company's resources are material, labor, financial and information resources. Digital technologies: artificial intelligence, additive technologies, blockchain, IoT, robotics, social networks, VR.

How can a formalized representation of the digitalization potential of a firm's ecosystem be used?

## **5 Directions for applying the potential of ecosystem digitalization**

It is important to note the institutional importance of ecosystems for the digital economy. It consists in forming a system of rational network coordination of economic entities and their connections in a single digital environment characterized by minimal barriers and maximizing the utility and productivity of infrastructure. The formed environment, as the foundation of the ecosystem, based on the trends of the digital economy. The analog components of the formed environment are the skills and entrepreneurship of economic entities, regulatory legal acts, institutions and public administration.

To create and strengthen inter-firm interactions in the conditions of digitalization, organizations need to develop the potential of the ecosystem through a system of information

and communication resources that allow economic entities to accelerate the processes of accumulation, processing and transmission of information, analysis of big data, and solve the problem of isolation, isolation and inconsistency.

The formalized potential of digitalization of the ecosystem (Popov, Simonova, 2022) makes it possible to assess the levels of participation of the stakeholders, the attraction of resources and the introduction of digital technologies in the development of the interaction space of the core of the ecosystem – the firm with the external environment.

The main directions of application of the formalized potential of digitalization of the ecosystem can be reduced to the following positions.

1. This is an opportunity to assess the use of potential: separately to attract stakeholders, the use of resources and the introduction of end-to-end digital technologies. Such an assessment can be carried out both on the basis of an expert survey and on the basis of available statistical data.

2. This is an assessment of the impact of various components of the ecosystem on the development of its other elements. It is possible to assess the impact of stakeholders on the use of ecosystem resources, or the impact of the introduction of digital technologies on the participation of stakeholders in the development of the ecosystem. These estimates can be obtained using correlation analysis and expert opinion. This means formalizing the principles of managing the company's ecosystem.

For example, the level of impact of the introduction of digital technologies on the participation of SH stakeholders in the development of the firm's ecosystem will be determined by functional dependence:

$$SH = f(II, AT, BC, IoT, RB, SM, VR), \tag{1}$$

where II – artificial intelligence, AT – additive technologies, BC - blockchain, IoT – Internet of Things, RB - robotics, SM – social media, VR – virtual reality.

On the other hand, the level of influence of available resources on the introduction of digital technologies (DT) has the form:

$$DT = f(M, L, R, I), \tag{2}$$

where M - material, L - labor, K - financial, I – information resources.

The level of influence of stakeholders of the ecosystem on the introduction of DT also has the form of dependence:

$$DT = f(B, G, C, A, S), \tag{3}$$

where B - business, G - government, C - consumers, A – education/science, S – mass-media.

3. This is the development of a general analytical model of the digitalization potential of the ecosystem based on multifactorial econometric modeling taking into account the interactions of all elements of this potential.

For example, the potential of digitalization of the ecosystem (Pot) depends on the levels of activity of stakeholders of the ecosystem (SH), the introduction of DT and the use of available resources (RS):

$$Pot = f(SH, DT, RS) \tag{4}$$

4. This is an assessment of the threshold values of factors for the development of the digitalization potential of the ecosystem, after which the company acquires the optimal configuration of ecosystem elements for business development.

5. It is a tool for developing a strategy for the development of the ecosystem based on identifying weaknesses in the application of various factors of its external space.

Thus, the scientific novelty of the obtained result lies in the development of a formalized potential for digitalization of the firm's ecosystem, which develops tools for analyzing economic ecosystems.

## 6 Conclusions

In this study the following results were obtained.

Firstly, the analysis and criticism of previous studies were carried out, which demonstrated the relevance of formulating the problem of developing the formalized potential of digitalization of the ecosystem.

Secondly, the main components of the external space of the company are identified: stakeholders, resources and end-to-end digital technologies.

Thirdly, the main factors forming the potential of digitalization of the ecosystem are identified. Stakeholders are divided into representatives of business, government, consumers, education/science, and mass-media. The resources are material, labor, financial and information. Digital technologies: artificial intelligence, additive technologies, blockchain, IoT, robotics, social networks, VR/AR.

Fourthly, various principles of managing the ecosystem based on the formalized potential of digitalization of the ecosystem are presented.

The theoretical significance of the obtained result lies in the development of a tool for analyzing the digitalization of the ecosystem, complementing the theory of ecosystem analysis. The practical significance consists in the development of an applied apparatus for assessing the digitalization of the ecosystem.

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