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Cross-Sectoral Digital Platform as a Tool for Innovation Ecosystem Development

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Abstract: At present, issues of ecosystem self-organization and the mechanisms for their sustainable development have been insufficiently explored in academic literature. The key idea of our research is that for enterprises interacting in different industries based on a network partnership, a special tool is needed to ensure the openness of interaction between participants in the transfer of knowledge, technology, information, and resources. The authors argue that the development and practical implementation of a cross-sectoral digital ecosystem platform will allow for the synchronizing of the scientific and technological progress of several industries, making the most effective use of the synergistic effect from the interaction of ecosystem actors and ensuring the transparency and openness of the ongoing processes therein. The authors demonstrate their propositions with the example of unmanned aircraft system (UAS) industry. The proposed model and mechanism of cross-sectoral interaction can be replicated in different technological niches, such as robotics, neurotechnology, quantum technologies, etc. The conclusions arising from the conducted research provide scientists, government bodies, and decision-makers with the necessary information for a better understanding of practical mechanisms and tools that allow for the implementation of self-organization and sustainable development in modern innovation ecosystems.

Keywords: innovation ecosystem; sustainability; self-organization; cross-sectoral platform; technology platform; project selection; reputation

1. Introduction

The modern economy is represented by many organizations and enterprises acting in various industries. Accelerated digitalization poses new challenges for organizations and the global market as a whole and encourages the modification of techniques and methods in management decision-making, changing its speed and the "mentality" of the relationships between market participants.

Building inter-organizational relationships, and collaboration in ecosystems, is virtually analogous to building networks. This process presupposes the ability to adapt to the environment, perform flexible transformations, and create new organizational structures through self-organization.

Carmen Joham et al. [1] define self-organization as "the ability of a non-centralized system to create a strategic response to a change in its environment" (p. 2376). Self-organization is characterized by the formation of patterns, stability, adaptability, and dynamics [2].

Noteworthily, the concepts of "innovation ecosystem" and "digital platform" are often misused in modern science and practice. Currently, Russian official documents view a digital ecosystem as a set of services, including platform solutions, of a single group of companies, or a company and partners that allow users to receive a wide range of products and services within a single seamless integration process. The ecosystem can involve closed and open platforms [3]. According to the definition given in the concept of the Ministry of Economy [4], a digital ecosystem is a customer-centric business model that combines two or more groups of products, services, or information (own production and/or other players) to meet the final needs of customers (security, housing, entertainment, etc.).

In our opinion, a digital platform is only a tool for self-organization of various types of social ecosystems (business, entrepreneurial, regional, urban, rural ecosystems, etc.).

In the article, we propose to define an innovation ecosystem as an open and self-developing system of network equality of economic actors that self-organizes on the basis of a special safe environment formed as a result of energy exchange (new knowledge, technologies, information, or unique resources). The advantages of the formation and development of social ecosystems include the creation of a new quality of life, the implementation of principles and the achievement of goals for the sustainable development of society, expanded opportunities for producers, and the removal of geographical barriers.

Like any complex system, the development of an innovation ecosystem is uncertain and unpredictable. Ecosystems are difficult to control, although they can be directed and influenced. In fact, any controlling influence should be considered as "intervention", which, at first glance, contradicts the fundamental principles of ecosystems [5], with the principle of self-organization being one. In addition, a very important aspect that deserves attention is the openness and transparency of innovation ecosystem platforms for all participants (ease of connection, transparency in the ranking of goods and services, etc.). There is the so-called paradox of openness (the tension between value creation and capture in joint innovation).

Due to difficulties in implementation of these very important principles (self-organization and openness) in practice, the ecosystem approach is not fully "operationalized" in the economy.

In our opinion, Barbara Gray [6] expressed accurately enough the very definition of the intervention concept: it is "to improve the quality and the likelihood of alliance success" by exerting an influence on the interaction among alliance partners through "reducing restraining factors or increasing driving factors". Inter-organizational collaboration can be promoted through regulation ("intervention") [7].

Since ecosystems are gradually becoming a private regulator of commodity and social relations and, therefore, they are able to influence the preferences of people and their access to information, this area needs special regulation tools (interventions) in order to ensure the sustainability of both the ecosystem as a whole and its individual participants. In our opinion, the development and practical implementation of a digital ecosystem platform should become one of the most important areas of regulation (intervention). Its purpose is to operationalize self-organizing processes in the ecosystem and ensure the transparency and openness of the processes taking place therein.

The problem of ensuring self-organization of enterprises–participants in ecosystems is undoubtedly very complex and multifaceted. Its solution should begin with theoretical development and a search for technological foundations for the implementation of ecosystem projects, being currently cross-sectoral, and based on various technological platforms.

This work is organized as follows: in Section 2, related works on cross-sectoral technology platform are presented. Section 3 is about the research methodology. Section 4 is devoted to the development of a model for managing the high-tech industries based on the mechanism of cross-sectoral interaction. In Section 5, different technologies for the formation of digital platform architecture for cross-sectoral ecosystem are considered. In Section 6, an intelligent system for assessing the effectiveness of a cross-sectoral ecosystem is proposed. The results are discussed in Section 7 to highlight the implications, opportunities for future research, and recommendations for practitioners. Finally, the limitations of our work are presented in Section 8.

2. Literature Review

Currently, the concept of an innovation ecosystem is gaining great popularity among market participants and researchers worldwide, which suggests a new organizational and economic model of interaction between participants in economic activity [8–11].

The concept of ecosystems has found application in science, business, and politics. The term "business ecosystem" was originally used and introduced into management science terminology by James F. Moore [12]. He defined "business ecosystem" as "an economic community supported by a foundation of interacting organizations and individuals—the organisms of the business world" [13]. Several years later, a number of authors [14–16] gave rise to a real research boom, having significantly expanded and enriched the concept of Moore.

The ecosystem model is based on an evolutionary approach that assumes flexibility, dynamism, and adaptability instead of strict determinancy. Indeed, nowadays, companies that strive to develop innovatively and be cost-effective are increasingly dependent on other organizations and businesses in their environment. It is the ecosystem as an organizational and economic model that most appropriately fits this requirement. An ecosystem can be viewed as "a set of actors with varying degrees of multi-lateral, non-generic complementarities that are not fully hierarchically controlled" ([17], p. 2264). Kapoor [18], for instance, views an ecosystem as "a set of actors that contribute to the focal offer's user value proposition".

Subsequently, the concept of an ecosystem has become an attractive basis for reasoning various system designs, which has influenced the creation of many research directions in this area. In particular, they include ecosystems of entrepreneurship, knowledge, business, innovation, digital platforms, etc. [19–26]. An ecosystem is focused on the interaction of actors, system infrastructure, and its underlying processes. This interaction comes from more traditional concepts of clusters, industrial areas, and regional innovation systems [27–29].

According to Zhao and Zeng [30], an innovation ecosystem can be seen as a self-organized evolution system that is associated with environment dynamically. It consists of members that evolve together, including firms; consumers; markets; and the natural, social, and economic environments [31]. It promotes the co-evolution of innovation groups and innovation environment by connecting and transmitting material flow, energy flow, and information flow [32]. It is more dynamic and evolutionary than an innovation system. Adner and Kapoor [33] noted that technology substitution is not merely the competition between two technologies. It is the competition between the two technology ecosystems as well. Components and complements bring challenges to the emergence of a new technology ecosystem [34]. They also provide opportunities for extending old technology ecosystems. When a technology is seen as part of a system, the value that the technology can bring to its users depends on the technology itself as well as interaction between the technology and other system elements, including technological elements and social-economic factors [34,35].

Historically, the ecosystem approach to management in Russia has replaced the rigid vertical hierarchical approach that was attempted to be implemented in practice some decades ago. Then there was an interest in infrastructure projects, and ultimately the attention of researchers focused on ecosystems—network structures with nodes (centers, hubs) equal in strength and power. Competition is completely absent, and symbiosis of all participants prevails in such ecosystems, being ideal structures. Nowadays, this approach has become dominant in the formation of new management models for innovation processes.

It should be noted that 15 years ago, Ludwig von Bertalanffy described systems theory, revealing the concept of an open, complex, self-organizing, self-regulating, and self-developing system [36]. Synergetics of interdisciplinary industries can be the key to solving problems of entrepreneurial activity. Synergy resulting from the joint action of many subsystems provides a transition to a new qualitative level of development of the system as a whole [37].

Extensive digitalization of the economy leads to the emergence of novel forms of cooperation between enterprises, and complexity of the existing forms of business organization at all levels [38]. In these conditions, the phenomenon of cross-sectoral interaction, that is, interaction between actors from various sectors of the economy, based on the creation of new business models and carried out through end-to-end digital processes in a single information space in accordance with the principles of decentralization and digital transparency, has been manifested [38–40].

To organize cross-sectoral interaction, appropriate mechanisms implemented according to the ecosystem principle using platform technologies are required.

Over the past few years, the process of transition to digital channels has been observed all over the world, and the ongoing transformations are radically transforming the economy. Now, cross-sectoral digital platforms play a key role in accelerating access to knowledge, economic growth and job creation, equality and participation of different groups, institutional accountability, efficiency of science, and new opportunities for innovation at any economic level. In the absence of resources to meet the sustainable development goals (SDGs), organizations will need to collaborate to make a measurable impact on the lives of people and on the planet. Cross-sectoral digital platforms contribute to the fulfilment of most sustainable development goals because they are a critical cross-sectoral and cross-cutting issue in addition to being an underlying infrastructure or technology for specific development sectors.

As noted above, the emergence of new industries at the intersection of technologies, and new technology markets at the intersection of industries, does not allow one to explicitly identify them as a particular complex, industry, or a sector. The emergence of new forms of business organization, being often hybrid, is an inevitable process caused by progress.

A technology platform is a communication tool aimed at enhancing efforts to create promising commercial technologies and new products and services; attract additional resources for research and development based on the participation of all stakeholders (business, science, government, civil society); and improve regulatory framework in the fields of scientific, technological, and innovative development [41].

However, in Russia, technological platforms have not proven themselves to be an effective mechanism for the development of new technologies. This was partly because of offline interaction among platform participants carried out within associations in the absence of modern organizational and economic instruments for the development of innovations, and was directive in nature, implying the availability of budgetary funding. Participation in technology platforms was often formal and did not provide practical benefits for its participants [42].

It is well known that high-tech industry is the basis of the country's innovative development, affecting the interests of a large number of stakeholders, including manufacturing enterprises, the state, investors, contractors and suppliers, service companies, research and educational organizations, and consumers.

An innovation ecosystem of high-tech industries is an organizational model for interaction of high-tech industry enterprises, research organizations, small innovative enterprises, and educational institutions, as well as development institutions and regulatory bodies in a single digital circuit in order to facilitate the development and production of high-tech products [43].

The digital platform of the cross-sectoral ecosystem in the context of influencing the development of innovation ecosystems provides seamless integration of measures to support innovative projects, synchronization of scientific and technological progress of several industries, and more effective interaction of all actors of the innovation ecosystem, creating a synergistic effect from such interaction.

The socio-economic effect of the creation of ecosystems is as follows:

1. Ensuring the growth of shareholder and consumer value of companies. The synergy of cross-industry interaction allows companies to enter new markets with the lowest costs and time costs, ensuring maximum consumer coverage, including at the expense of other ecosystem participants.
2. Reduction of transaction costs. Digital transformation allows one to intensify business processes, optimize the management structure. By sharing resources, logistics costs are reduced, production flexibility is increased, and business cycles are accelerated.
3. Intensification of innovation. The ecosystem's tools and services provide access to technology, and financial and human resources; protect the results of intellectual activity; and allow for the use of digital systems for managing innovative projects and R&D. Accelerated testing and piloting of R&D results in an ecosystem in which subsequent commercialization takes place.
4. Accessibility to new markets. The ecosystem creates new markets and provides access to them for small and medium-sized businesses by integrating large companies into supply chains and reducing transaction costs. Provides administrative, consulting, marketing, and financial support to export companies.
5. Reducing corruption risks. The principle of digital transparency increases the coordination of economic relations between the entities of the ecosystem, ensures the traceability and transparency of operations, and allows one to quickly eliminate legal and regulatory barriers that create corruption precedents.

At the same time, a digital ecosystem is a virtual platform that is usually based on an IT platform, where interaction between participants is carried out in business-to-business (B2B), business-to-consumer (B2C), business-to-government (B2G), and consumer-to-government (C2G) formats. Digital ecosystems provide interaction between government, business, and consumer sectors of the economy.

As an example of digital ecosystem, consider the concept of collaborative economy. The collaborative economy, sometimes called the sharing economy, covers a great variety of sectors and is rapidly emerging across Russia. Digital sharing platform is one of the circular economy business models and is aimed at increasing the intensity of existing products use through their rental or sharing. Since marketing offers use rather than ownership of goods, the digital sharing platform contributes to reducing resource flows [44,45]. Another interesting aspect is that, although the closest groups of individuals have had shared objects and life experiences since the beginning of humanity, in recent years, the development of new technologies and the growth of digital platforms have led to an exponential increase in relationships of exchange between people [45]. Many people have already used or are aware of collaborative economy services, which range from sharing houses and car journeys, to domestic services.

Currently, innovation ecosystems are being transformed into digital ecosystems, providing seamless integration of measures to support innovative projects, and more effective interaction among ecosystem actors.

Innovation and industrial ecosystems [8,9], being transformed into digital ecosystems, do not fully provide coverage of all participants, from scientists to industrial entrepreneurs, in creating high-tech products. This is due to disunity of actors of these ecosystems, duplication of functions, lack of subject focus, and strategic goal-setting of ecosystem functioning.

It is necessary to create an ecosystem that will ensure synchronization of scientific and technological progress of several sectors of the economy and maximize the efficiency of synergistic effect from the interaction of ecosystem actors.

3. Research Methodology

The study assesses approaches to the formation of a digital platform for a cross-sectoral ecosystem, which provides network interaction of subjects of various sectors of the economy within the ecosystem, the generation of innovative business models, the launch of end-to-end digital processes at the intersection of industries, and the provision of organizational and economic tools and services to its participants.

To achieve this goal, the case study method was applied. The authors conduct a study on the example of the UAS ecosystem, which is a high-tech field of activity, in which there is a need to synchronize the scientific and technological progress of several industries and the most effective use of the synergetic effect from the interaction of ecosystem actors.

Description of the UAS Ecosystem

Unmanned aircraft systems, as defined by the International Civil Aviation Organization, are aircraft and related systems operated without a pilot on board [46].

The designation "unmanned aerial systems" (UAS) is a synonym for the commonly used designations "drone" and "unmanned aerial vehicles". Within the framework of the study, only the civilian segment of the UAS industry is considered as an object of strategic development management.

The industrial production of civil unmanned aerial systems covers a wide range of enterprises from various industries (aviation, space, radioelectronic, metallurgy, and chemical), which determines its cross-sectoral nature.

Additionally, among the significant factors confirming the cross-industry nature of UAS ecosystem, there is a set of advanced production and digital technologies used in the production of UAS.

Thus, under the UAS industrial complex, within the framework of the study, a group of industrial enterprises, innovative companies, and research and educational organizations engaged in the development and production of UAS, as well as developers of related technologies, is considered.

The use of civilian UAS is increasing in agriculture, power generation, oil and gas industry and mining, insurance and security, logistics and construction, and entertainment (Figure 1). The use of UAS allows companies from various economic sectors has created new business models and provided services that were previously unavailable [47].

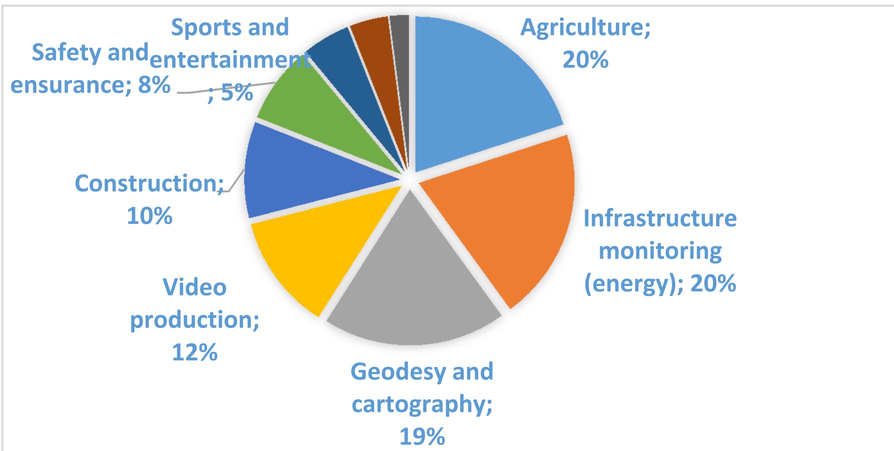

Figure 1. UAS market segments by industry, 2018–2020. Source: own elaboration.

According to the Aeronet Association of Operators and Developers of Unmanned Aircraft Systems [48], the volume of the Russian UAS market is about 2% of the world, which is about $0.4 billion in monetary terms.

The growth potential of Russian-made UAS is forecasted in the commercial segment. At the same time, the consumer segment of UAS will be fully occupied by foreign manufacturers, primarily Chinese ones [49].

The Russian market for civilian UAS, equipment, and services rendered with the help of drones is currently unformed and requires significant investments [50]. At present, the state support of the industry is carried out through the instruments of the National

Technological Initiative, the Industry Development Fund, Innovation Promotion Fund, the Ministry of Industry, and Trade of the Russian Federation [51].

As of the beginning of 2021 in Russia, according to data from open sources [51], about 180 public and private organizations can be attributed to the UAS industry—from public corporations, including leaders of the aviation industry, to small university design groups and start-ups providing services using UAS.

The public sector of UAS developers and manufacturers is represented by the corporations Rostec State Corporation, Roscosmos State Corporation, and others. Among the Russian companies with state participation—manufacturers of civilian UAS—one can distinguish ZALA Aero Group, BP Technologies LLC, etc.

To a greater extent, the production of consumer and commercial drones in Russia is mainly carried out by private companies, including RTI Systems Concern, Kronshtadt Group of Companies. Based on the existing structure of BAS developers and manufacturers, as well as economic indicators of industry development, it can be concluded that the industrial production of UAS in Russia is at the initial stage of its formation. At present, there are no full-cycle industrial UAS production facilities in Russia. The domestic market for commercial and consumer drones is occupied by foreign manufacturers, mainly Chinese.

For the development of small innovative companies, start-ups, and university laboratories, access to serial industrial production is actually closed due to the presence of complex of administrative (regulatory bans), organizational (lack of a component base, production base), economic (lack of funding), and political (problems safety, public perception) risks.

An analysis of the UAS industry shows that there is sufficient scientific and technical groundwork, and a technological base, for launching large-scale industrial production of civilian UAS and their components in Russia. At the same time, production can be focused on saturating its own market and entering international markets.

Despite the potential of the UAS market, its development in Russia is restrained by certain barriers, one of which is the lack of a mechanism for the strategic development of the industry.

A cross-sectoral ecosystem for the high-tech UAS industry can become such a strategic development mechanism.

The authors used methods of control theory, methods of structural and system analysis of complex objects, systems modeling, and scientific formation and development of complex technological systems as methods to achieve the research goal.

4. Cross-Sectoral Technology Platform as a Tool for Self-Organization of Actors: Towards the Creation of a Cross-Industry Ecosystem

Cross-sectoral ecosystems are created under the influence of industrial digital transformation and are planned to be the most effective organizational and economic unit of network interaction in the future [52].

An idea of cross-sectoral ecosystems implies the interaction of its participants in a single information system according to the standards and principles specified by the ecosystem for all participants. The ecosystem should ensure interaction among the participants and provide them with services and various organizational and economic tools to enable economic activity. The nature of the paradigm of digitalization of the economy is to implement an advanced mechanism for a cross-sectoral ecosystem for the development of new high-tech industries based on a digital platform.

It is digital platforms that usually become a spontaneous basis for the formation of ecosystems since companies attract new users at the lowest costs through such platforms and form the added value of the product together with all platform participants, including consumers.

The architecture of a digital platform is developed depending on the intended purpose thereof. It consists of the platform operator being its management body; the environment for interaction between participants–suppliers and consumers, developers, regulatory, and supervisory authorities; IT services and applied tools; infrastructure–information processing facilities; and data sources [53].

Actually, there are many types of digital platforms, and the typification proposed above covers their nomenclature, taking into account the technological features of the end-to-end digital technologies used therein: Big Data, neurotechnologies and artificial intelligence, new production technologies, distributed ledger systems, quantum technologies, industrial internet, wireless communications, and robotics.

A digital platform of cross-sectoral ecosystem is a global information platform that provides network interaction among subjects of various sectors in the economy within the ecosystem, the generation of innovative business models, the launch of end-to-end digital processes at the intersections of traditional industries, and the provision of organizational and economic tools and services to its participants.

Technologically, a digital platform of cross-sectoral ecosystem is a secure information system for data accumulation, analysis, and management that ensures the interaction of participants and provides platform participants with services and tools for conducting business activities.

There are different types of platforms depending on their functional characteristics. Table 1 provides the authors' analysis of the functionality of various types of platforms for compliance with the purpose of the digital platform of cross-sectoral ecosystem. The analysis has shown that such a platform can combine almost all types of platforms presented in Table 1 in terms of functionality.

Table 1. Types of digital platforms by functional characteristics. Source: own elaboration.

Types of Platforms	Functionality	Compliance with the Purpose of the Digital Platform of Cross-Sectoral Ecosystem
Technological	Availability of IT resources and end-to-end digital technologies for the development of applied software and services	They can be an integral part of the platform, expanding its practical significance for software developers and ensuring its technological self-sufficiency
Sectoral	Interaction between participants in the same industry or market	They are fully included in the architecture of the platform and can be represented as the base platform
Functional	Availability of specialized software (ready-made solutions) for ultimate consumers	They should be included in the platform as one of the services
Infrastructural	Access to digital infrastructure and development tools	They can be used to solve practical problems in the development of the platform
Corporate	Digitalization of management processes and interaction of economic entities	They should be included in the platform as one of the services
Information	Information access	They should be included in the platform as one of the services
Marketplaces	Access to consumers, ensuring engagement of the parties	One of the important elements of the platform to be implemented as a service

The digital platform of cross-sectoral ecosystem allows one to complete the system components in the process of functioning. The platform architecture allows various industry companies to perform joint activities in the absence of organizational hierarchy elements in the ecosystem on the principles of equality and self-regulation. In this context, cross-sectoral ecosystem based on a digital platform will be a mechanism for strategic development of new high-tech industries.

According to the authors' previous research [54], the digital platform of cross-sectoral ecosystem has a number of key features:

- the platform operates on the basis of the principles of digital transparency and reliability of information—organizations authorized for control and monitoring purposes must have access and observe all chains of cooperation links, transactions, and contractual relationships of ecosystem entities;

- the broadest coverage of all possible participants in target industries: federal and regional authorities, regulators, industry associations, industrial enterprises, service companies, research and educational organizations, financial sector, development institutions, small innovative enterprises, and ultimate consumers;
- the ability to integrate third-party platforms: state information systems, platforms of development institutions, regulators, banks, etc.

The digital platform is a tool to create cross-sectoral ecosystems for the development of new industrial sectors and for organizing cross-sectoral interaction among participants therein [55].

The socio-economic effect of ecosystem creation is as follows:

- Growth of shareholder and consumer value of companies. The synergy of cross-sectoral interaction allows companies to enter new markets with the lowest costs and time costs, ensuring maximum consumer coverage, including at the expense of other ecosystem participants.
- Decrease in transaction costs. Digital transformation allows intensifying business processes and optimizing the management structure. By resource sharing, logistics costs are reduced, production flexibility is increased, and business cycles are accelerated.
- Intensification of innovative activity. The ecosystem's tools and services provide access to technology and financial and human resources, protect the results of intellectual activity, and allow for the use of digital systems for managing innovative projects and research and development (R&D). Accelerated testing and piloting of R&D results in the ecosystem with subsequent commercialization is offered.
- Accessibility of new markets. The ecosystem creates new markets and provides access for small and medium-sized enterprises thereto. Administrative, consulting, marketing, and financial support to export companies is provided.
- Reducing corruption risks. The principle of digital transparency increases the coordination of economic relations between the ecosystem entities, ensures traceability and transparency of operations, and allows one to quickly eliminate legal and regulatory barriers that create corruption precedents.

The introduction of cross-sectoral ecosystems in the industry will allow for the intensification of the innovative development of high-tech industries and ensure the retention of leadership positions in the high-tech sector. High-tech sector is represented by a set of industries characterized by a high level of R&D costs and advanced scientific and technical potential. The enterprises of the sector create advanced technical solutions and have the rights to the results of world-class intellectual activity, provided with the highest category of personnel, and are competitive in the world market.

The level of expenditures on R&D in the sector exceeds 6% of the money turnover [56].

An example of organizing cross-sectoral interaction is the initiative to create a single ecosystem of cross-sectoral cooperation within the Eurasian Economic Union, which includes tools for industrial cooperation, staffing, and educational and logistics infrastructure.

Currently, the development of industrial production of unmanned aircraft system (UAS) for civil applications is an urgent task in Russia. Many strategic programs and documents are devoted to solving this complex problem, including the Strategy for the Development of the Information Society in the Russian Federation for 2017–2030 and others [57–61].

In this article, the authors have made an attempt to attempted to solve this large-scale problem by proposing the mechanism of the cross-sectoral ecosystem for strategic development of high-tech industries.

The creation of cross-sectoral ecosystem for the development of civil UAS is relevant due to cross-sectoral nature of its production. Ensuring cooperative links between related industry enterprises, dynamic development of production by small companies and start-ups, training of personnel for the unmanned industry, development of a regulatory framework, and the removal of regulatory barriers requires overall support for interaction between the actors in an actively emerging market.

5. Development of a Model for Managing the Development of High-Tech Industries Based on the Mechanism of Cross-Sectoral Interaction

The industrial production of UAS is characterized by a set of numerous linear and functional connections that arise at each level of the management system. In the current management structure, the development of new industries is hardly possible since in the Russian Federation, cooperation of related industries that create breakthrough products is carried out by directive and under the supervision of regulatory bodies. In the Russian Federation, the emergence of new industries happens at the level of small and medium-sized enterprises, reaching its development limits without state support.

In the process of designing and implementing a new model for managing the development of high-tech industries, one should take into account both the shortcomings of the current model and such external processes as digitalization, environmental friendliness, sustainable development, restrictive measures, etc., that affect the industrial complex as a whole (Figure 2).

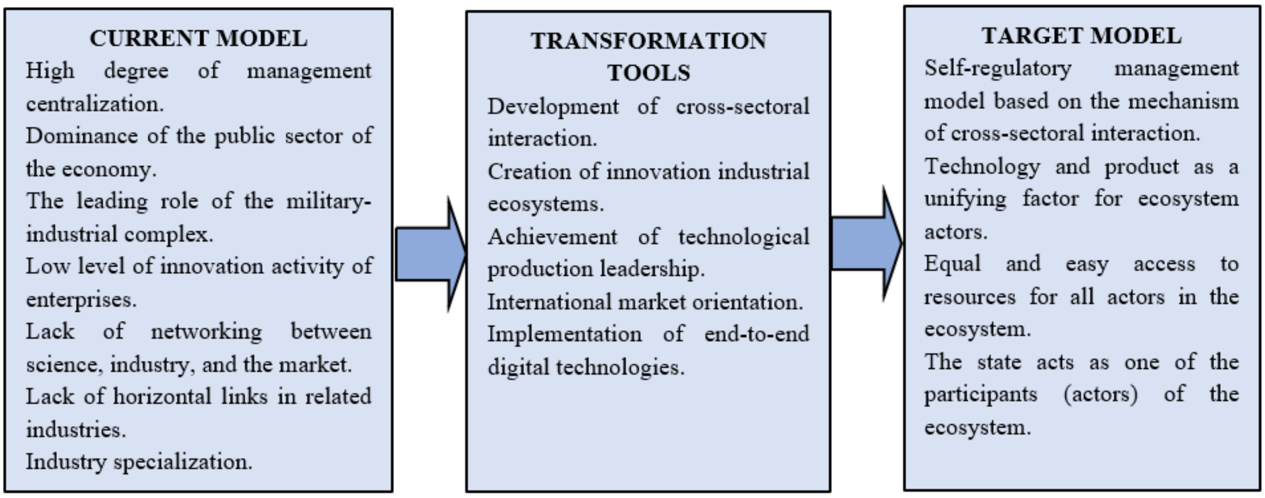

Figure 2. Transformation scheme for current industrial management model in the Russian Federation. Source: own elaboration.

The management model, being created on the ecosystem principles, allows each actor to optimize their own business processes in the ecosystem, to participate in chain production of value added of other participants, to reduce transaction costs, and to implement innovative projects, while receiving a powerful synergistic effect from interaction with other participants in the ecosystem [9].

The mechanism of cross-sectoral interaction, implemented in the ecosystem, has resulted from the evolutionary development of cluster and network models for organizing enterprises in the context of digital transformation. An international experience of creating consortia (Industrial Internet Consortium [62], IoT Consortium [63], etc.) in order to develop new technologies and promising markets shows the effectiveness of combining competencies of participants from various fields. Within the framework of consortia, regulatory, research and development, and organizational tasks of a specific technological sphere are primarily solved. However, such organizational formations generally retain the qualities inherent in directive centralized models for industrial management.

Characteristic features of the management model based on the mechanism of cross-sectoral interaction are as follows:

- Lack of a centralized ecosystem management body. Management is carried out by a collegial body—the ecosystem council, which includes representatives of all categories of participants. State management of the ecosystem is excluded.
- Cross-sectoral ecosystem is a distributed economic entity operating in the digital space. The ecosystem is open to all participants in the technological area, regardless of industry or territorial affiliation, form of ownership, or subordination.

- The ecosystem is a mechanism for strategic development of high-tech industries and provides cross-sectoral interaction of participants in order to achieve a synergistic effect from joint activities. The ecosystem is the subject of industrial policy but does not perform functions of an executive or regulatory body.
- The ecosystem provides equal access to resources and opportunities for participation in complex scientific and technological projects for both public and private organizations. This ensures equal participation of initiators of innovations in all stages of the product life cycle.
- The mechanism of cross-sectoral interaction ensures the expansion of horizontal and vertical connections among ecosystem participants, regardless of their corporate and industry affiliation.

The implementation of an ecosystem-based management model allows one to obtain practically complete and reliable online information in the context of the industry and the market. Implementation of the principle of digital transparency will allow one to track the entire value-added chain of each type of products and services implemented by ecosystem participants.

Structurally, the ecosystem-based management model consists of the following elements:

- An ecosystem management body is the ecosystem council, which comprises representatives of all categories of participants to carry out operational management of the ecosystem and implement the development strategy of high-tech industry.
- A digital platform of an ecosystem is a technological infrastructure that ensures implementation of cross-sectoral and information interaction and the provision of digital tools and services to ecosystem participants.
- Digital tools and services that provide participants with access to financial, technological, personnel, information, and administrative resources.
- Technological clusters of an ecosystem are centers of technological competence that collect, analyze, and process the results of scientific research and development carried out by ecosystem participants.
- A distributed network of ecosystem participants who have access to the ecosystem platform.

Implementation of these properties and features in innovation ecosystems is possible due to the public–private partnership (PPP) mechanism that allow one to create a portfolio of unique technologies in areas where long-term competitive advantages for consistently high profits can be achieved. Eventually, the actors form an accelerated technology transfer on the basis of the accumulated reserves.

The PPP mechanism is to be helpful for the development of digital and platform solutions in the field of technology transfer, for establishing effective communication channels between participants, and for attracting additional investments for the implementation of projects, involving infrastructure crowdfunding [64].

The transition to an ecosystem model for managing the development of high-tech industries will allow one to pursue a consolidated industrial policy. In parallel, the involvement of large enterprises in civil production, and the level of diversification of traditional industries, is increasing.

A model for managing the strategic development of UAS industry makes it possible to bring together the market participants. The ecosystem of UAS industry most fully realizes its potential regarding the totality of participants, technological areas, provided services, and tasks to be solved.

6. Formation of Digital Platform Architecture for Cross-Sectoral Ecosystem as a Tool for Self-Organization

The development and implementation of a digital platform for cross-sectoral UAS ecosystem are inevitably linked to the general trend towards digitalization of the economy (Table 2). The introduction of digital platforms in such key sectors of the economy as industry, energy, construction, and agriculture increases the rate of economic growth, creates new business models, provides opportunities for remote employment, and improves the quality of services [48].

Table 2. Technologies for a digital platform of cross-sectoral ecosystem.

Technologies	Application
Artificial Intelligence	- data processing; - launching intelligent systems for assessing, forecasting, and management decision-making; - increasing the efficiency of interaction; - ensuring the convenience of using platform services.
Big Data	- predictive analytics; - personalization of public assistance and services; - basis for management decision-making; - continuous data collection.
Cloud Computing	- increasing the availability for provision of facilities and services; - increasing the speed of service delivery; - public cloud.
Distributed Ledger	- contracting; - registration of rights.
The Internet of Things	- introduction of control sensors into the technical process; - providing remote control.
Digital Passport	- implementation of digital transparency principle; - ensuring interaction in the digital environment.

The created digital platform is built on the basis of a "customer-centric model", which has the following features [65,66]:

- "Horizontal" integration of information systems of market participants is provided at the intersection of economic sectors;
- An open application programming interface (API) that allows information systems of individual economic entities and applied digital platforms to be connected to the platform;
- End-to-end tools and services are formed according to the needs of ecosystem participants on a single data array;
- Uniform architectural principles and a continuously updated stack of platform technologies;
- Uniform digital profile and uniform participant identification system;
- Application of artificial intelligence technologies and automation of decision-making;
- Being the main architect of the platform, the state is an equal participant in the ecosystem.

Currently, there are about 250 state websites and information systems in Russia. The State Industry Information System (SIIS) can be symbolically attributed to industrial platforms at the macro-level; Relayr, Davra, Everywhere, Cerebra, Walson IoT, etc., are industrial platforms at the meso-level [67].

The platform being created is aimed at developing a specific cross-sectoral UAS market to unite all subjects of UAS industry, regardless of territorial, sectoral, or departmental affiliation. The digital platform is integrated with the existing IT platforms of federal authorities, development institutions, technology platforms, clusters, state corporations, and small and medium-sized enterprises.

In developing the organizational structure of a digital platform, the principles of pricing in the ecosystem outline, network effects, issues of platform competition, and strategic planning should be taken into account [68] (Figure 3).

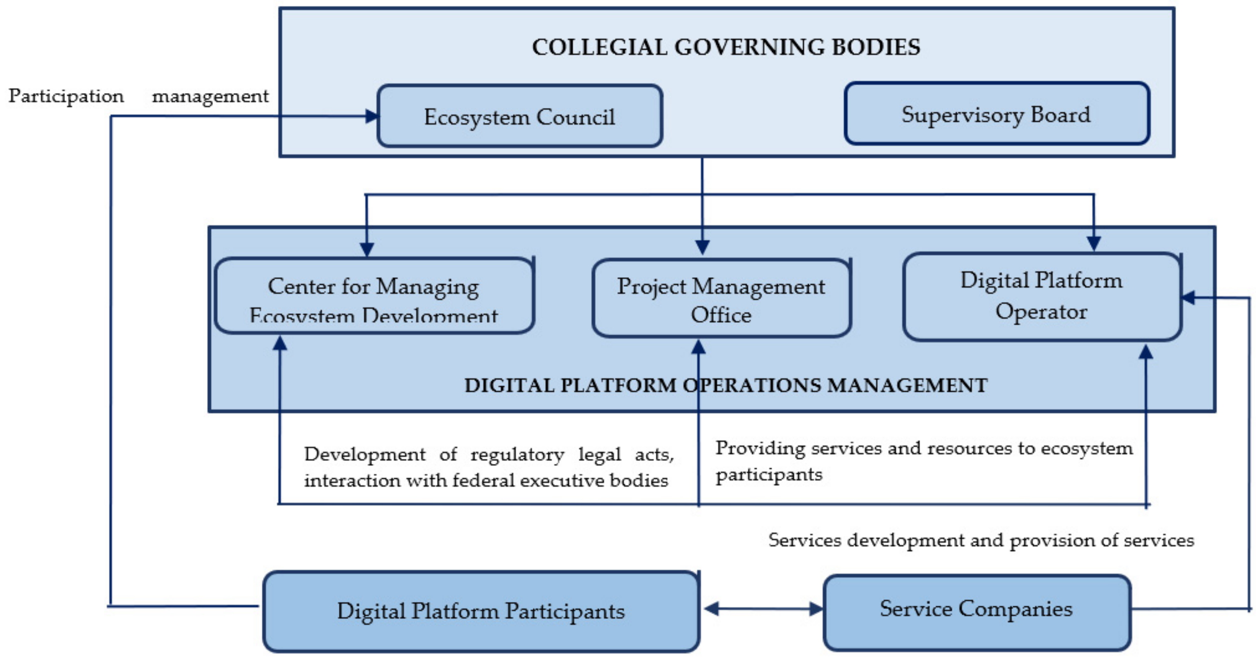

Figure 3. Organizational structure of a digital platform of cross-sectoral ecosystem. Source: own elaboration.

The organizational structure of the digital platform does not suggest a centralized management system, except for the digital platform operations management bodies, which report directly to the UAS Ecosystem Council. The platform operation and the interaction of its participants are carried out on the principles of self-government.

All subjects of the digital platform are endowed with powers and functionality within the framework of the strategic goal setting for the digital platform operation as an infrastructure basis for the cross-sectoral UAS ecosystem (Table 3).

When designing the platform architecture, strategic goals and objectives are taken into account that determine the composition of structural elements of the platform, principles of interaction between participants, and the technology stack.

Table 3. Functionality and powers of digital platform components within the UAS ecosystem.

Platform Component	Functionality and Powers
Supervisory Board	- coordination of interaction between the ecosystem and federal executive bodies in implementing the state industrial policy; - approval of the strategy for the UAS ecosystem development as a mechanism for strategic development; - coordination of industry standards, regulations, etc., with federal executive bodies; - supervision of activities of digital platform operations management bodies.
UAS Ecosystem Council	- providing conditions for complex interaction between various participants in the UAS ecosystem; - guiding digital platform operations management bodies; - coordination of activities of digital platform participants within the ecosystem; - formulating proposals for improving the state industrial policy in the context of UAS industry development; - consideration of proposals from ecosystem participants; - making decisions on project implementation within the ecosystem.

Table 3. *Cont.*

Platform Component	Functionality and Powers
Center for Managing UAS Ecosystem Development	- elaboration and updating of the strategy for UAS industry development; - undertaking analytical studies; - development of sectoral standards and regulations; - attracting new participants in the ecosystem; - expansion of international cooperation.
Project Management Office	- carries out selection and expertise of innovative projects; - provides participants with an access to ecosystem resources; - controls development and provision of digital tools and services to participants.
Digital Platform Operator	- operation of the digital platform; - provision of infrastructure to developers of digital services; - improving architecture of the digital platform; - ensuring data security, stability, and permanence of the platform.
Digital Platform Participants	- elaboration of proposals for the development of UAS industry; - implementation of innovative projects within the ecosystem; - participation in value-added chains of high-tech products.
Service Companies	- create digital services and tools; - provide offline services to ecosystem participants.

An analysis of functional, technological, and organizational solutions is carried out while designing the platform architecture (Figure 4). An ecosystem participant is the core of goal-setting for the processes to be built.

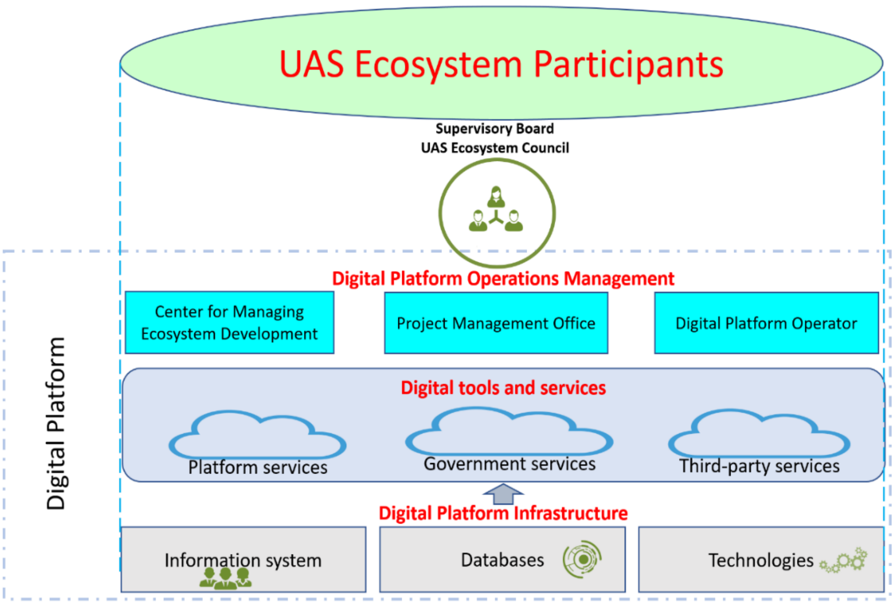

Figure 4. Digital platform architecture for cross-sectoral ecosystem. Source: own elaboration.

A management model based on the mechanism of cross-sectoral interaction considers shortcomings of the centralized model and creates similar conditions for the development of all subjects of high-tech industries operating at the intersection of technologies (Figure 5).

A cross-sectoral ecosystem is a self-governing distributed economic entity that provides its participants with equal access to resources, digital tools, and services (Figure 5).

The mechanism of cross-sectoral interaction is implemented through the creation of an ecosystem that unites all actors involved in the development and production of certain high-tech products at the intersection of industries and technologies. The creation of cross-sectoral ecosystems in the industry of the Russian Federation should be regulated and coordinated by the state.

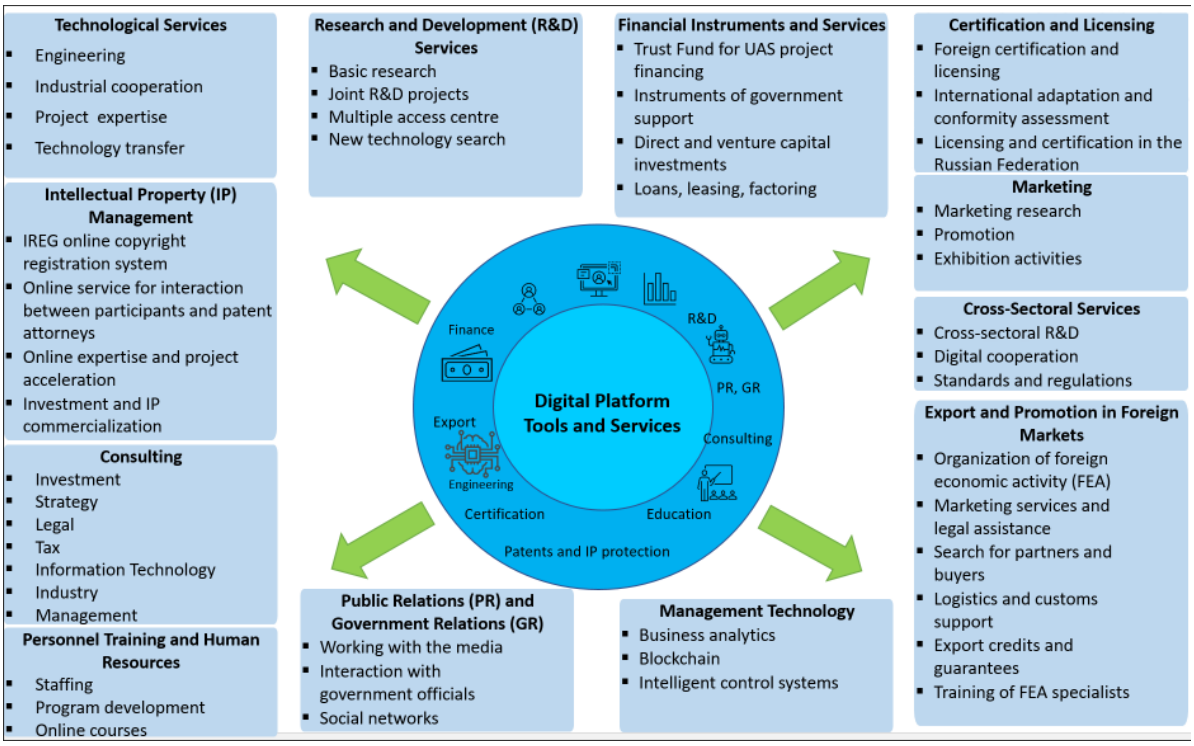

Figure 5. Organizational and economic tools and services of the digital platform.

Digital platform is an infrastructure core of the ecosystem management model. Digital platform provides an information environment for interaction between ecosystem participants, digital tools, and services. Participants of cross-sectoral ecosystem achieve a synergistic effect by reducing transaction costs, increasing the value added and services, and gaining simplified access to organizational and economic tools.

7. An Intelligent System for Assessing the Effectiveness of Cross-Sectoral Ecosystem

The key element in managing the system of state support for all sectors of the economy and functioning of development institutions is the assessment of their effectiveness. A system of criteria and key indicators for the efficiency of tools and services of the digital platform of the UAS ecosystem is based on sectoral comprehensive analysis and interconnection with national development goals.

In the context of the formation of an intelligent assessment system (IAS) of the effectiveness of the UAS cross-sectoral ecosystem, foreign and domestic research [69,70], systems of key performance indicators (KPIs) of development institutions, indicators of national programs, government support measures, and innovative development programs for state companies have been analyzed. Based on the analysis results, criteria, and indicators for assessing the effectiveness of each digital platform tool and service, an original system for assessing the effectiveness of the cross-sectoral ecosystem has been developed.

The intelligent assessment system based on artificial intelligence and Big Data technologies will provide support for management decision-making. Indicators for assessing the effectiveness of tools and services of a digital platform ensure online quantitative and qualitative assessment according to the selected criteria (Table 4). The proposed indicators can serve as a starting point for further development of threshold values for a specific digital platform, depending on the type, scale, key idea, or key project for cross-sectoral ecosystem creation.

Table 4. Key performance indicators of digital platform tools and services.

No.	Digital Platform Tools and Services	Performance Indicators
1	Cross-Sectoral Tools	number of new categories of products or services value added of products and services reduction of transaction costs amount of cross-sectoral R&D level of digitalization of production and administrative processes
2	Financial Instruments and Services	investment volume in production return on investment net present value capitalization of digital platform projects number of initial public offerings (IPOs) volume of the trust fund for UAS project financing volume of attracted venture capital investment amount of attracted grants, subsidies, and targeted financing
3	Technological Services	percentage of modern equipment number of patents introduced into economic turnover acceleration of operating cycles number of implemented technologies cost reduction with the implemented technologies
4	Consulting	number of completed consulting projects cost reduction within the framework of implemented consulting projects revenue growth within the framework of implemented consulting projects
5	Research and Development (R&D)	number of developed advanced production technologies internal costs for R&D share of innovative products in the total volume of goods, activities, and services number of implemented R&D number of international R&D
6	Intellectual Property Management	number of patents for inventions and utility models registered in the Russian Federation number of submitted international applications for inventions number of patents per employee number of publications per employee amount of royalties paid income from licensing agreements and sold patents
7	Personnel Training and Human Resources	number of employees who have undergone professional retraining or advanced training at the expense of the company number of conferences with an employee participated number of employees engaged in R&D number of developed sectoral educational programs and online courses percentage of Candidates and Doctors of Science in the ecosystem
8	Management Technology	labor productivity growth tax revenues to different type budgets highly productive jobs excess of the average salary in the sector wage growth
9	Export and Promotion in Foreign Markets	share of high-tech exports in the volume of manufactured products total exports of ecosystem participants volume of received export credits and guarantees
10	Marketing	participation in international exhibitions number of brands brought to the international market ecosystem brand awareness
11	Certification and Licensing	percentage of products certified according to international standards of total volume number of licenses obtained for manufacture and products
12	Public Relations and Government Relations	number of developed and adopted regulations public confidence in the UAS technology attendance level of ecosystem participants in social networks and media

The key performance indicators of digital platform tools and services should be brought to a unified system of performance indicators for the cross-sectoral ecosystem. The effectiveness of the ecosystem is proposed to be assessed according to the criteria of budget efficiency, scientific and technical potential, human capital development, financial and economic efficiency, and leadership potential. The aggregated indicators allow assessing a cumulative effect of the general ecosystem functioning and form modularization criteria to assign a weight for each indicator by the method of an expert survey. In general, the module weight cannot be more than 1.

As noted earlier, the major difference between the ecosystem models and the other ones is the principle of self-organization. The control system chain is to implement the so-called feedback in order to ensure the implementation of these principles both for each actor in the ecosystem and for the system as a whole. Feedback is to inform the interaction partner about the perception of his activity by others, the reaction thereto, and the results and consequences of this activity. It is to transfer estimated or corrective information about an action, event, or process to the original source and to monitor the emergence of new information, tracking all kinds of trends. Based on the knowledge (information) gained, this approach allows the system to constantly increase its potential via a self-adjusting loop [10]. It is implementation of the self-adjusting loop that allows the ecosystem to be resistant to external and internal challenges, avoiding or minimizing them through a constant increase in its potential using preventive measures.

A self-adjusting model allows one to monitor the KPIs that "provoke" the desire of actors to be ecosystem-attractive, implementing an internal policy of corrective actions. Since there is no vertical control that determines the structure and place of each actor from above in the system, the main mechanism for the formation of an ecosystem and the distribution of roles therein are the desire of a particular actor and its usefulness for other participants.

The actor's self-adjusting loop involves preventive measures, being constant monitoring of external challenges, mobilization of the current development strategy, response measures, and control over the results. An actor, participating in the implementation of a certain project, is able to minimize the occurrence of threats and risks in conditions of interaction with other actors in the ecosystem. Consequently, this will provide an opportunity to adequately assess and control the current situation; make informed management decisions; and, if necessary, make adjustments to the tactics and strategy of actions.

An assessment of the actor's reputation should be constantly carried out in the ecosystem, from the "entry" of the enterprise into the ecosystem, and after each project implementation. Cross-validation allows an actor to accumulate scores, form his own positive ecosystem reputation, regularly monitor the reputation of other actors, influence the level of their reputation through his own assessment, and make independent decisions about cooperation in each individual project.

The tasks of the platform in the context of implementing self-organization principle of the ecosystem are as follows:

1. Selection of actors for a particular role in the ecosystem;
2. Selection of innovative projects;
3. Continuous analysis and evaluation of project implementation effectiveness;
4. Risk management and minimization;
5. Providing necessary information for the formation of a development strategy for each actor.

Thus, a system of KPIs for the cross-sectoral ecosystem should be formed to be used by the IAS having the following key features:

- Continuous analysis of ecosystem indicators based on digital passports of participants and data from ecosystem tools and services;
- Self-learning based on artificial intelligence and Big Data technologies;
- Analysis of external factors' impact on ecosystem indicators;
- Forecasting long-term trends depending on external conditions.

The IAS-based algorithms for assessing the effectiveness of a cross-sectoral ecosystem should take into account such external parameters as macroeconomic indicators, national development goals, and sectoral indicators. A target value is set for each performance indicator. The value achievement confirms the effectiveness of ecosystem services and tools assessed by this indicator. If the indicator exceeds by over 5%, it corresponds to high efficiency, and if it fails to achieve more than 10%, it means that the tool is inefficient and has to be improved.

An algorithm for assessing the effectiveness of a cross-sectoral ecosystem is shown in Figure 6.

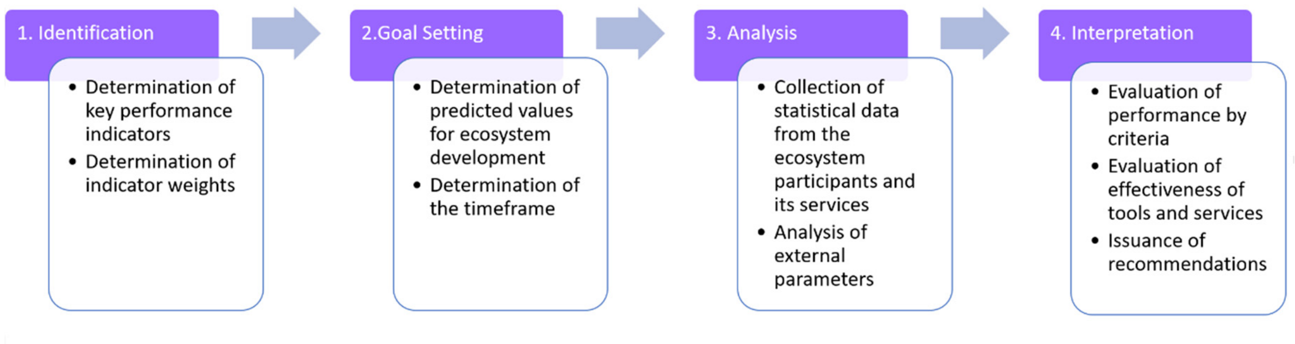

Figure 6. Algorithm for assessing the effectiveness of a cross-sectoral ecosystem. Source: own elaboration.

As a rule, intelligent systems are composed of a knowledge base, logical input–output mechanisms, a self-learning system, information channels, and systems for interaction with the external environment [71]. The use of specialized software tools based on artificial intelligence technologies is a promising direction for assessing complex multi-component systems [72] (Figure 7).

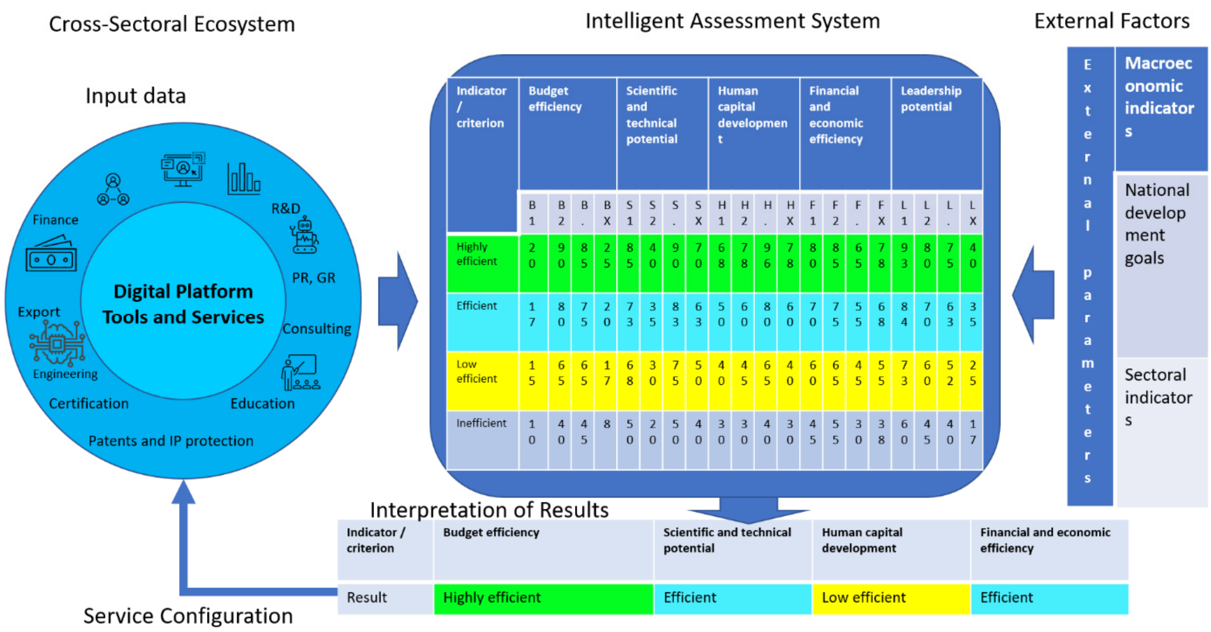

Figure 7. Block diagram for an intelligent system to assess the effectiveness of a cross-sectoral ecosystem. Source: own elaboration.

The formula for calculating the effectiveness of a specific indicator is as follows:

$$P = Kr/Ke \times C$$

where Kr is the real value of the indicator for the period,

Ke is the expected value of the indicator for the period,
and C is the weight of the indicator.

Thus, the developed intelligent assessment system permits one to evaluate a lot of factors that affect the performance of a cross-sectoral ecosystem and its tools and provide data for management decision-making online at sectoral level.

8. Conclusions

In general, modern theoretical and methodological approaches to managing the development of high-tech industries correspond to the present requirements in the context of digitalization. However, in practice, outdated models and approaches are still used, despite the platformization of the economy and the emergence of new forms of management in the form of various ecosystems. The authors have investigated the phenomenon of the emergence of new industries and markets at the intersection of technologies and industries and have proposed a cross-sectoral ecosystem to be used as a promising development mechanism thereof.

In the context of the study, a cross-sectoral ecosystem is considered to be a mechanism for the cross-sectoral interaction of an unlimited number of actors of a certain technological sector of the economy in a platform-based single digital circuit that provides digital tools and services to ensure accelerated growth and reduce costs through synergy from multilateral interaction based on common rules and principles of self-government, digital transparency, networking, and equality for all participants.

The object of research is the industrial production of unmanned aircraft systems since it has a cross-sectoral nature due to the concentration of a large number of new technologies and cooperation ties of various industries involved in the UAS development, production, sale, and maintenance.

The study proposes a model for managing the development of high-tech industries based on the mechanism of cross-sectoral interaction, which takes into account the shortcomings of the current management model and creates equal conditions for the development of all participants in high-tech industries at the intersection of technologies. The key advantages of the ecosystem model are decentralization, functioning in a unified distributed digital space, ensuring equal access to resources, digital tools, and services for the participants. The ecosystem model allows carrying out consolidated state innovation policy. The introduction of cross-sectoral ecosystems in the industry of the Russian Federation should be coordinated by the state. This requires elaboration of a strategy for the development of high-tech industries based on the mechanism of cross-sectoral interaction.

The technological basis for cross-sectoral ecosystem is a digital platform that implements an information environment for interaction between ecosystem participants and provides digital tools and services. The architecture of the digital platform does not imply a centralized management system, and the operational management of the platform is carried out by the UAS Ecosystem Council.

Monitoring of the UAS ecosystem is carried out by a developed intelligent system for assessing the effectiveness of the cross-sectoral ecosystem. The IAS concept implies that a system based on artificial intelligence technologies constantly conducts a multifactorial assessment of ecosystem performance indicators, taking into account the influence of external parameters, development of benchmarking indicators, and sectoral indicators.

The system of indicators that assesses the effectiveness of the ecosystem according to the criteria of budget efficiency, scientific and technical potential, human capital development, financial and economic efficiency, and leadership potential is interconnected with the digital tools and services of the platform, which provide the most relevant information from the ecosystem participants. The assessment algorithm is based on development targets for each indicator, being generated by the intelligent assessment system on the basis of relevant indices, external factors, and sectoral indicators. The IAS takes into account the target value of the indicator; evaluates the value achievement or failure, taking into account external factors; and interprets the results based on the target performance indicators.

The following major risks and measures, which need to be addressed, should be specified in transition to an ecosystem management model (Table 5).

Table 5. Risks that affect implementation of the ecosystem model, and measures to reduce it.

Risk List	Risk Minimization Measures
Legal and methodological risks: - lack of regulatory documents defining the procedure for the formation and functioning of ecosystems and digital platforms, the procedure for participation in ecosystems, and the procedure for obtaining and providing services within ecosystems; - changes in legislation, introduction of prohibitive and restrictive norms.	- development of regulations, involvement of professional communities, and public organizations to formulate common approaches to the functioning of ecosystems in the Russian Federation; - functioning of a permanent expert council within the ecosystem, including representatives of the state, business, and the expert community; - development of measures for protecting interests of the ecosystem participants.
Organizational risks: - lack of the state strategy for the ecosystem development; - lack of approaches and practices for the introduction of ecosystems in industry; - absence of a government body to coordinate the issues of ecosystem creation and coordination in industry.	- development of the state strategy for the introduction of ecosystems in the real sector of the economy; - development of a road map for the transition to a model for managing the development of high-tech industries based on the mechanism of cross-sectoral interaction; - empowerment of federal government implementing industrial policy to coordinate the process of ecosystem creation and coordination.
Infrastructure risks: - data leakage, cyber-attacks on the digital platform infrastructure; - stealing trade secret information, and other fraudulent activities; - stability and continuity of the ecosystem and the digital platform operation.	- implementation of a data management system, including its protection, standards, and usage principles within the ecosystem; - maintaining the continuity of the digital platform operation by introducing hardware and software tools for duplicating critical infrastructure; - creation of a digital platform operator for a cross-sectoral ecosystem, ensuring its operability.
Monopoly risks: - limited access to markets for companies outside the ecosystem; - technological and informational discrimination of market participants not included in the ecosystem; - reduced technological development due to adherence to certain technologies and rejection of others.	- development of antimonopoly tools that take into account the ecosystem specifics; - functioning of expert and supervisory councils.
Integration risks: - development of uniform standards and rules for interaction within the ecosystem; - inappropriate integration processes of interaction; - providing ecosystem participants with software solutions and their adaptation to a specific participant.	- early identification of possible integrations; - providing access to the integrated system/systems; - application of open technologies.

It can be concluded that the prerequisites for the introduction of new management models for the development of high-tech industries have been created in the Russian Federation. An example of the mechanism of cross-sectoral interaction of the UAS industry can be replicated in different technological niches, such as robotics, neurotechnology, and quantum technologies. The widespread introduction of the mechanism will enable the country to be positioned among the leaders in technological development and promptly respond to emerging technological challenges.

Thus, a cross-sectoral ecosystem is a mechanism for strategic development of high-tech industries, ensuring intersectoral interaction between industrial enterprises and research and educational organizations of diverse departmental subordinations. It is coordinated by federal executive authorities in cooperation with development institutions, ensuring the interaction of ecosystem actors in a single digital space and providing participants with tools and services for the implementation of innovative projects, and rapid introduction of world-class high-tech products to the markets.

As part of ensuring the conditions for the strategic development of the UAS industry in Russia, it is necessary to develop and adopt a program at the state level for the development of the production of civil unmanned aerial systems. At the program level, the creation of an appropriate coordinating body at the federal level should be defined, the area of responsibility of which is the formation of a strategy for the scientific and technological development, development, and production of UAS; the formation of a favorable environment for UAS market in Russia; and ensuring the export of high-tech products.

9. Limitation and Future Research Directions

In the context of extensive digital transformation, the transition to an ecosystem management model in the economy should not cause great difficulties despite certain problems and barriers. Currently, there is no regulatory framework for the functioning of global technological ecosystems in the Russian Federation. There is an acute problem of restricting competition and providing access to ecosystems on a non-discriminatory basis. The process of providing access to state information systems and platforms has not been worked out, and the issue of creating a databank in a unified format of ecosystem participants is still unresolved. [73]. Furthermore, the implementation of the principle of digital transparency requires a detailed study of some information security issues, such as:

- The data safety of the ecosystem participants;
- Access to trade secret information;
- The reliability and completeness of information;
- The operational stability of the digital platform;
- Providing access for military–industrial complex enterprises.

The problems outlined above require both theoretical and practical solutions, so that the ecosystem concept can fully realize its significant potential in the Russian economy. Moreover, it is crucial to refer to the issue regarding digital maturity at the micro-level (at the level of individual enterprises).

In such conditions, the concept of socio-technical system analysis [74] is also especially relevant, emphasizing the integration of the technical system of the organization (tools and procedures) with the social system (roles and relationships between participants). It is important part that ecosystem actors fully realize that such internal processes are both natural and necessary for the introduction of new technologies in an organization.

In addition, such aspects of organizing interaction in innovation ecosystems based on the so-called spiral models are very important [75–77].

It will be also promising in future research to analyze the impact of the proposed model of the cross-industrial ecosystem on the socio-economic development of regions and countries through an assessment of vertical and horizontal spillover effects.

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